CALFED BAY-DELTA PROGRAM

CALFED SCIENCE FELLOWS PROGRAM

In cooperation with the

California Sea Grant College Program

FELLOWSHIP APPLICATION COVER PAGE

APPLICANT TYPE [X] Postdoctoral Researcher [ ] Ph.D. Graduate Student

PROJECT NUMBER

PROJECT TITLE Mercury interactions with algae: Effects on mercury bioavailability in the San Francisco Bay Delta

FINANCIAL SUMMARY

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Will animal subjects be used? [ ] Yes [X] No
APPROVAL DATE: PROTOCOL #: PENDING:

Does this application involve any recombinant DNA technology or research? [ ] Yes [X] No

Proposed Research

I. INTRODUCTION/QUESTION/ OBJECTIVES

One of the major environmental concerns in the San Francisco Bay and Delta is mercury contamination (Thompson et al. 2000). The estuary is highly contaminated with mercury as a result of historic gold and mercury mining in its watersheds. When that mercury reaches the sediments of the estuary, it can be transformed by bacteria to methyl mercury (MeHg), which is the organic form that bioaccumulates in the food chain. MeHg bioaccumulates to concentrations of >0.4 parts per million (ppm) in San Francisco Bay fish, far exceeding the San Francisco Bay Regional Water Quality Control Board screening value of 0.2 ppm (SFEI 2000). As a result of those elevated concentrations, there are fish consumption advisories in place in the estuary (SFEI 2000). The advisories are primarily for pregnant women because mercury may affect fetal brain development and result in neuromotor, visual, and sensory impairments in developing fetuses (Mahaffey 2000). Mercury is also considered a threat to wildlife, particularly the endangered California Clapper Rail (Schwarzbach et al. 2006). Mercury decreases California Clapper Rail egg viability, and the last ~1000 breeding individuals live in the tidal marshes of the estuary (Schwarzbach et al. 2006).

To address these health and environmental concerns, research on MeHg bioaccumulation in the food chain is needed. Although research suggests that fish and birds accumulate most of their MeHg from the food chain (Boudou and Ribeyre 1997), the mechanism for mercury uptake into phytoplankton at the base of the food chain is not known. Phytoplankton concentrate MeHg by a factor of 10^5, making them the largest single step in MeHg bioaccumulation (Mason et al. 1995; Mason et al. 1996). Moreover, uptake of MeHg to phytoplankton can be modeled by understanding the chemistry of the surrounding waters. Accordingly, I plan to examine the chemical parameters that affect MeHg association with phytoplankton.

One water chemistry variable that may be particularly important for elucidating how MeHg is accumulated in phytoplankton is the amount and quality of dissolved organic matter (DOM) in the water. Organic matter enters the estuary's waters through a variety of sources, including terrestrial runoff (i.e. humic matter), wastewater treatment plant inputs, and breakdown of marine organisms. MeHg and inorganic Hg(II) may bind to the DOM through complexation to reduced sulfur groups (e.g. thiol groups) on amino acids and humic substances (Amirbahman et al. 2002; Benoit et al. 2001). Only a small portion of MeHg or Hg (II) may bind to oxygen functional groups, such as carboxylic groups on humic substances (Amirbahman et al. 2002; Reddy and Aiken 2001).

In the San Francisco Bay estuary, high MeHg concentrations have been associated with high dissolved organic carbon (DOC) (Conaway et al. 2003). That relationship between MeHg and organic matter in San Francisco Bay has been observed for a number of size fractions, including the filtered fraction (< 0.45 μm), the colloidal fraction (1 kDa - 0.45 μm), and the <1 kDa fraction (Choe and Gill 2003). A positive correlation between DOC and mercury has also been observed in a number of other systems, including lakes and rivers (Babiarz et al. 1998; Grigal 2002; Watras et al. 1998).

The association between mercury and DOM may be a missing link for understanding how mercury is accumulated by phytoplankton. Previous research has demonstrated that DOM may alter processes that occur on phytoplankton surfaces (such

as uptake of metals) by binding to cell surfaces (Campbell et al. 1997). That DOM binding likely also increases the sorption of mercury to the cell surface, based on research by Gagnon and Fisher (1997) showing that fulvic coatings on particles enhanced the sorption of MeHg and Hg(II) to particle surfaces. We hypothesize that as a direct result of this three-way interaction between phytoplankton, DOM, and mercury, DOM influences mercury uptake to phytoplankton. That hypothesis is supported by results from Pickhardt and Fisher (in press) demonstrating that high concentrations of DOC increased MeHg uptake to phytoplankton.

Although Pickhardt and Fisher (in press) observed that DOC enhanced MeHg accumulation in phytoplankton, the mechanism for MeHg uptake by phytoplankton remains elusive. One possible mechanism, which is supported by these studies on the linkage between phytoplankton, DOM, and mercury, is that phytoplankton are deliberately taking up DOM and accidentally acquiring MeHg that is associated with that DOM. That explanation is consistent with previous studies showing that phytoplankton uptake of MeHg is an active process (Moye et al. 2002; Pickhardt and Fisher in press). Moreover, phytoplankton are known to uptake a variety of organic materials from the water, such as siderophores and vitamin B_{12} (Morel et al. 2004; Swift and Guillard 1978).

If phytoplankton are deliberately taking up DOM and acquiring MeHg as an accidental associate, we might expect that the quality of the DOM affects MeHg uptake to phytoplankton. For example, in areas with low carbon quality, such as the Central Delta (Stepanauskas et al. 2005), phytoplankton might take up less DOM and therefore accumulate less MeHg. Such a mechanism would explain observations that fish from the Central Delta have lower mercury concentrations than those from the rivers that empty into the Delta (Foe et al. 2003).

Furthermore, it is possible that MeHg and Hg(II) are preferentially associated with highly bioavailable fractions of the DOM (e.g. glutathione), exacerbating the MeHg accumulation for phytoplankton that are uptaking high quality DOC. This hypothesis is supported by recent research that suggests that the composition of the DOM may be more important than bulk concentration (Han et al. 2006). For example, Han et al. (2006) found that low concentrations of glutathione and phytochelatin, both ligands with biological origins, were important for complexing dissolved mercury. Knowing the fraction of the DOM with which the mercury is associated could be important for determining how mercury is accumulated in phytoplankton.

Understanding how DOM quality affects MeHg accumulation in phytoplankton is instrumental for ecosystem managers to address prospective effects of land use changes and wetland restorations. For example, current plans call for remediating 40,000 ha of agricultural land to wetlands, which is about 10% of the total Delta area (Stepanauskas et al. 2005). However, there is concern that wetland restoration could increase MeHg fluxes (Grigal 2002), creating unsuitable habitat for fish and pisciverous birds. Those increased MeHg fluxes may be associated with the high production of DOC in wetlands (Grigal 2002). Creation of freshwater wetlands from former agricultural areas may also change the quality of the DOC and result in more reactive DOC (Bossio et al. 2006). This proposal will determine how changes in DOC composition affect MeHg uptake to phytoplankton by using DOM isolates from a variety of sites, including wetlands and marshes, to study MeHg accumulation. Accordingly, this work could help determine the

suitability of constructed habitats. This outcome relates directly to CALFED's priority goal of determining how abiotic drivers, including contaminants, affect habitat quality.

To address the need for studies on DOM and mercury in the San Francisco Bay Delta, this proposal has three objectives: (1) to determine the bioavailability of MeHg and Hg(II) associated with DOM by adding radioisotopes of MeHg to phytoplankton cultured in DOM isolates from the estuary; (2) to test the association between MeHg and Hg(II), phytoplankton, and DOM quality by lagrangian sampling in San Joaquin River; and (3) to develop a model to predict the processes controlling MeHg uptake to phytoplankton, and thus to the food chain.

II. Approach/plan of Work

To characterize DOM and look at the bioavailability of MeHg bound to DOM, I am proposing an interdisciplinary collaboration between the community mentor, Dr. Brian Bergamaschi, United States Geological Survey, and the research mentor, Dr. Nicholas S. Fisher, State University of New York at Stony Brook. Dr. Bergamaschi's research focuses on characterizing DOM and food web dynamics. Dr. Fisher's research focuses on using radiotracers to look at the bioavailability of metals to organisms, including phytoplankton. By combining these two different fields, this proposal will be able to both characterize the DOM and to examine the effects of DOM composition on uptake to phytoplankton at the base of the food chain. Specifically, we will test the following:

> Hypothesis 1: Low quality DOC limits MeHg uptake to phytoplankton in the Central Delta and thus decreases bioavailability to the food chain.
>
> Hypothesis 2: MeHg and Hg(II) concentrations are correlated with high quality DOM, not bulk DOC concentrations, and that association affects mercury concentrations and partitioning as DOM composition changes down the San Joaquin River.
>
> Hypothesis 3: The composition of the DOM and other water chemistry variables can be used to develop a biogeochemical model to predict mercury in fish hotspots in the estuary and Delta.

Sites for Hypothesis 1

To look at the bioavailability of mercury associated with phytoplankton, we will compare a variety of sites (Figure 1) in the Sacramento and San Joaquin Rivers and Delta with differing organic matter composition. Some of these sites have been previously characterized (Stepanauskas et al. 2005). Those characterizations have shown that sites in the Central Delta generally have low quality DOC of terrestrial origin and low nutritional value (Stepanauskas et al. 2005). In contrast, DOC from the Sacramento River at Hood and the San Joaquin River at Vernalis has high bioavailability to the microbial community and a higher fluorescence ratio than samples from the Delta, indicating a relatively larger contribution of phytoplankton-derived DOC (Stepanauskas et al. 2005).

Based on these previous characterizations, we will use the following sites, illustrated in Figure 1: (1) The Sacramento River at Hood; (2) The San Joaquin River at Vernalis; (3) Frank's Tract, a tidal wetland in the Central Delta; (4) Mandeville Tip, a natural freshwater marsh also in the Central Delta; (5) Prisoner's Point, a deep water channel that represents an average for Delta-exposed water; (6) Brown's Island, a brackish marsh that is the most westerly of our sampling sites, and (6) Twitchell Island Drain, a below sea level island that receives DOC from agricultural run-off. This range of sites should allow us to work with DOM before and after it has been transformed by processes in the Delta. Furthermore, isolates of DOM have already been collected from these sites and are well characterized in a wide variety of ways at considerable expense (tens of thousands of dollars), allowing us to leverage past work to begin our culture studies on the effect of DOM composition on MeHg uptake to phytoplankton.

This sampling scheme will also allow us to compare our results on bioavailability to phytoplankton with previous field observations on MeHg accumulation in clams and fish in the Delta. Some preliminary field results suggest that largemouth bass and white catfish in the Central Delta may have lower mercury concentrations than those from the Sacramento and San Joaquin Rivers (Davis et al. 2003; Foe et al. 2003). We will test the hypothesis that low quality DOC limits MeHg uptake to phytoplankton and thus explains the low concentrations of mercury in fish observed in the Central Delta. This goal addresses CALFED's priority topic area on understanding the divers that affect habitat quality.

Laboratory Experiments for Hypothesis 1

To test the effect of DOM quality on uptake to phytoplankton, three species of phytoplankton will be cultured in each of the DOM isolates described in the previous section. Those cultures will later be divided into a subculture for a control, a subculture for MeHg addition, and a subculture for Hg(II) addition. Then, a laboratory synthesis will be conducted to generate $CH_3{}^{203}HgCl$ from $^{203}Hg^{2+}$. The $CH_3{}^{203}HgCl$ and $^{203}Hg^{2+}$ will be added to the respective treatments. This will generate a high number of samples, typical of this method. Those samples will be analyzed for concentrations of $CH_3{}^{203}HgCl$ and $^{203}Hg^{2+}$ in water and phytoplankton, using established techniques (Pickhardt and Fisher in press).

The phytoplankton species will consist of the diatom *Cyclotella meneghiniana*, the chlorophyte *Chlamydomonas reinhardtii*, and the cryptomonad *Cryptomonas ozolini*. These species were chosen because they are present in San Francisco Bay and have been used on past studies (Pickhardt and Fisher in press). Furthermore, they represent a range of cell sizes, with differing surface area to volume ratios. The surface area to volume ratio is an important consideration because as cell size increases, the proportionately reduced surface area means that metal uptake is limited by the rate of diffusion of the metal to the cell surface (Sunda and Huntsman 1998). In contrast, in smaller cells (<30 μm diameter), the rate limiting step is transport across the cell membrane (Sunda and Huntsman 1998). Accordingly, differences in the amount of uptake in different size cells might indicate which processes affect metal transport across the cell membrane. The three species of phytoplankton will be cultured in the various DOM isolates, and then radioactive mercury will be added.

To obtain radioactive MeHg, a laboratory synthesis from Hg(II) will be conducted. The Fisher laboratory regularly receives $^{203}HgCl_2$, with a specific activity of 152-325 KBq μg^{-1}, which will be used to synthesize $CH_3{}^{203}HgCl$. Following established methods (Pickhardt and Fisher in press; Rouleau and Block 1997), $^{203}HgCl_2$ will be methylated with methylcobalamin ($C_{63}H_{91}CoN_{13}O_{14}P$). The resulting $CH_3{}^{203}HgCl$ will be extracted with methylene chloride (CH_2Cl_2) (Pickhardt and Fisher in press). The CH_2Cl_2 will then be evaporated and the $CH_3{}^{203}HgCl$ will be collected in MQ and then stored in the dark in dilute Optima grade hydrochloric acid (HCl).

Next, $^{203}HgCl_2$ or $CH_3{}^{203}HgCl$ will be added to cultures of phytoplankton held in the DOM isolate from each site and concentrations of mercury in water and phytoplankton will be measured daily for a week. After addition of the spikes, final concentrations of mercury in water will range from 0.7 to 1.5 nM of $^{203}HgCl_2$ and 0.5 to 0.7 nM of $CH_3{}^{203}HgCl$. To determine how those concentrations will change, measurements of the radioactivity of mercury in water and phytoplankton (collected on filters), will be made with a LKB Pharmacia Wallac 1282 Compugamma equipped with a well-type NaI(TI) detector, following protocols previously established in the Fisher lab (Pickhardt and Fisher in press). Measurements of radioactivity will then be converted into concentrations, based on the initial concentration to radioactivity ratio. Given those concentrations, volume concentration factors (VCFs) will be calculated to assess and compare the MeHg and Hg(II) accumulation in phytoplankton cultured in different types of DOM.

Additional experiments using heat killed phytoplankton will carried out using the same protocols. The heat killed phytoplankton cells will allow us to differentiate mercury that is actively uptaken by phytoplankton versus that which is passively sorbed to the cells. Comparisons of mercury uptake to live versus dead cells have been previously used to demonstrate that the uptake of MeHg by phytoplankton is an active process (Moye et al. 2002; Pickhardt and Fisher in press).

Sampling for Hypothesis 2

To test the hypothesis that MeHg and Hg(II) concentrations are correlated with the quality of the DOM and that association affects partitioning and uptake to phytoplankton, we will conduct lagrangian sampling in San Joaquin River. By following the same water mass as it moves down river for three days, we will be able to follow the water as it receives DOM inputs from various sources, including algal production, sewage, and animal waste (Kratzer et al. 2004). Because we expect that the quality of the DOM will change as a result of these different organic matter sources, we will be able to determine which components of the DOM are correlated with MeHg and Hg(II) concentrations. Based on research in Galveston Bay, Texas (Han et al. 2006), we expect that the concentration of glutathione may be a particularly important component of the DOM for mercury binding. The aromaticity of the sample might also be an important indicator of DOC binding to metals (Mcknight et al. 1992). We will measure these parameters as described below.

This sampling effort will also be an opportunity for us to relate our laboratory experiments from the first part of this study to algal uptake of mercury in the field. Portions of the San Joaquin River, such as the Stockton Deep Water Ship Channel, have low dissolved oxygen concentrations associated with organic matter from algal blooms

(Kratzer et al. 2004). Because we expect that the quality of DOM may affect uptake to phytoplankton, sampling during the blooms will allow us to determine if quality of DOM effects MeHg depletion from water.

Another important and understudied aspect of an algal bloom is its decay. Previous research has demonstrated that the decomposition of blooms may be an important period for remobilization of metals from sediments (Luengen et al. in press; Schoemann et al. 1998). During the decay of the spring phytoplankton bloom in South San Francisco Bay, concentrations of DOC and filtered MeHg increased (Luengen et al. in prep). However, the relative bioavailability of that DOC was not assessed. By measuring both the MeHg concentration and the DOM composition during decomposition events, we will be able to predict the biological fate of MeHg mobilized during those periods.

The sampling of the San Joaquin River will be conducted in conjunction with an existing USGS project on nitrate and organic carbon inputs into the San Joaquin River. This will allow us to take advantage of additional parameters measured by the USGS, including chlorophyll-a and nutrients. These parameters will also help us develop our model in hypothesis 3.

Characterization of DOM for Hypothesis 2

To evaluate the composition of the DOM collected from San Joaquin River, we will collect samples for DOC, particulate organic carbon (POC), specific ultraviolet (UV) absorbance, fluorescence, and glutathione concentration. DOC and POC measurements will provide information about the concentration of bulk organic matter, and its distribution between particulate and dissolved phases. Specific UV absorbance, measured at 254 nm, is an indicator of the percent aromaticity of the sample (Weishaar et al. 2003). Aromaticity has been correlated with the solubility and dissolution of cinnabar (HgS ore) (Waples et al. 2005), and may be an important indicator of the amount of mercury associated with DOC. Fluorescence, measured as a ratio of 450 and 500 nm under excitation at 370 nm, is an indicator of the amount of DOC of planktonic versus terrestrial origin (Mcknight et al. 2001). Finally, we will measure glutathione because it is likely an important ligand for binding mercury (Han et al. 2006).

Water samples will be collected and analyzed according to standard methods in the Bergamaschi lab. Briefly, samples for DOC concentrations will be filtered through a 0.45 micron glass fiber filter (GF/F), acidified to pH 2, and refrigerated until analysis (within two weeks). DOC concentrations will be measured on acidified samples with a Shimadzu TOC-5000A carbon analyzer according to the method of Bird et al. (2003). Samples for POC will be collected on a 0.45 micron GF/F, dried at 60 degrees C and weighed for TSS. Total inorganic sediment will be determined after combustion. Laboratory absorbance of discrete samples will be measured in a 1-square centimeter quartz cuvette using a Cary model 300 photometer (Varian, Inc, Palo Alto, CA). Samples for fluorescence will be measured with a SPEX FluoroMax-3 spectrofluorometer in a 1-square centimeter quartz cuvette using a 150-watt Xenon lamp. Excitation will range from 255 to 600 nm in equally spaced increments of 11 nm, with emission from 250 to 700 nm. All optical samples will be analyzed after equilibration to 25ºC.

Mercury Collection and Analysis for Hypothesis 2

To measure MeHg and Hg(II) associated with the DOM and during algal bloom and decomposition events in the San Joaquin River, we will collect unfiltered and filtered (0.45 μm) surface water samples. The samples with be collected with a peristaltic pump equipped with acid-cleaned Teflon tubing attached to an aluminum pole as per the methods that have been used to collect trace metal clean samples in San Francisco Bay (Flegal et al. 1991). Filtered (0.45 μm) water will be obtained by attaching an acid-cleaned polyethylene filter to the tubing of the pump. All samples will be collected into acid-cleaned PFA Teflon bottles. Samples for total mercury (Hg_T) analyses will be preserved by addition of 0.5% BrCl. Samples for MeHg analyses will be preserved by addition of either 0.4% HCl for freshwater or 0.2% H_2SO_4 for saltwater, as described by Parker and Bloom (2005).

Water samples for MeHg analyses will be analyzed by distillation, aqueous phase ethylation, volatile organic trapping, and analyses by cold vapor atomic fluorescence spectrophotometry (CVAFS) (Bloom 1989; Horvat et al. 1993). Water samples for Hg_T will be analyzed using CVAFS following tin chloride reduction and two-stage gold amalgamation trapping (Bloom and Fitzgerald 1988; Gill and Fitzgerald 1987).

To ensure accurate results, certified reference materials (CRMs) for Hg_T in water (ORMS-3) will be analyzed. Although there is no CRM for MeHg in water, we will digest and dilute DORM-2, a dogfish CRM, to check accuracy, as per the methods routinely used by Nicolas Bloom (CEO, Studio Geochimica). We will also check for acceptable MeHg recovery after distillation by using matrix spikes and matrix spike duplicates.

Model for Hypothesis 3

To predict MeHg and Hg(II) bioavailability to phytoplankton, will use the water chemistry parameters collected during the lagrangian sampling of the San Joaquin River and the results from our studies on uptake of MeHg and Hg(II) to develop a biogeochemical model. The effort will build on statistical models that I have developed to assess which factors govern trace metal concentrations in South San Francisco Bay (Luengen et al. in press). We plan to use the statistical package Systat to conduct our analyses. Those analyses will include the development of general linear models to determine which components of the DOM are important for predicting mercury concentrations.

The biogeochemical model will also include a spatial component, developed from our results in the first section looking at DOM quality and mercury accumulation at different sites in the Delta. Development of a spatial model to characterize anticipated stressors is one of the key components listed for Priority Topic 4: Habitat Availability and Response to Change. Thus, this component of the research will directly address CALFED's needs.

We will compare our model results with data collected on MeHg and Hg(II) concentrations in water and fish from the Sacramento and San Joaquin Rivers and Delta. The comparison will include a spatial component, based on the hypothesis from Foe et al. (2003) and Davis et al. (2003) that organisms in the Central Delta have relatively low mercury concentrations. Those researchers based their hypothesis on measurements of mercury concentrations in largemouth bass, white catfish, inland silversides, bluegill

sunfish, signal crayfish, threadfin shad, gambusia (mosquito fish), and clams (*Corbicula* sp.). We will also compare our data on water concentrations of Hg_T and MeHg to those measured by Domagalski (1998; 2001) for the Sacramento River basin. Additional measurements of MeHg and Hg(II) in the rivers are available in Choe and Gill (2003), Choe et al. (2003), and Conaway et al. (2003). The overall goal is to use our results on DOM quality and DOM interaction with phytoplankton and existing data on mercury concentrations to explain patterns and predict mercury bioavailability at other sites in the estuary.

Timeline

During the first year of this study, I will conduct the laboratory studies on MeHg and Hg(II) uptake to phytoplankton cultured in isolates with differing DOM composition. I expect to complete those studies in nine months, and then write-up the results for publication in a peer reviewed journal by the end of the first year. I also plan to present those results at the State of the Estuary Conference in October 2008.

The second year of this study will focus on the lagrangian sampling in the San Joaquin River. That sampling will be conducted at least twice that year, to capture seasonal variability in DOM composition. I anticipate that work will result in at least two publications- one on DOM composition and the other on association with MeHg and Hg(II). One of those publications will be completed by the end of the second year. In March 2008, I also plan to present results from the first study at the Society for Limnology and Oceanography (ASLO) Ocean Sciences meeting. That fall, I will present preliminary results from the San Joaquin River Study at the State of the Estuary conference.

During the third year, I will finish the second publication from the San Joaquin sampling. I will also use the previous results to develop the biogeochemical model for the third component of this proposal. By the end of the third year, I will complete the paper on the biogeochemical model. I also plan to attend the Ninth International Conference on Mercury as a Global Pollutant in Guiyang, China in June 2009. That will be an opportunity for me to present a synthesis of my research and interface with other mercury researchers. The final summary of my work will be presented at the State of the Estuary Conference in October 2009.

III. OUTPUT/ANTICIPATED PRODUCTS AND OR BENEFIT

Anticipated Outcomes

This research will result in 4 published papers. They will be (1) Effects of DOM composition on MeHg and Hg(II) uptake to phytoplankton; (2) DOM composition in the San Joaquin River; (3) Association between MeHg, Hg_T, DOM, and algal blooms during continuous sampling of the San Joaquin River; and (4) A biogeochemical model for predicting MeHg availability to phytoplankton in the San Francisco Bay and Delta. The expectations for when these will be completed and the anticipated per year outcomes are given in the previous "timeline" section.

Benefits to the Scientific Community, Calfed, and Regional Water Quality Control Board

One of the most important outcomes of this research will be an increased understanding of factors controlling MeHg uptake to phytoplankton. That outcome is important scientifically, since phytoplankton have been observed to actively accumulate MeHg, but the mechanism is not known (Moye et al. 2002; Pickhardt and Fisher in press). Because phytoplankton are at the base of the food chain and transfer of MeHg from water to phytoplankton is the largest single step in mercury bioaccumulation (Mason et al. 1995; Mason et al. 1996), elucidating that mechanism will help predict what conditions will cause high MeHg concentrations in fish.

Knowing how mercury enters the food chain is also important for CALFED's mission. CALFED's Preferred Programs, which shape the agency's direction over the next 30 years, include a Water Quality Program, which includes components on reducing the impacts of trace metals and reducing mercury concentrations (CALFED Bay-Delta Program 2000). To reduce the impacts of mercury pollution, CALFED will benefit from knowing what factors make that mercury bioavailable. Furthermore, research on how MeHg and Hg(II) are associated with DOM will help elucidate how mercury is transported in the estuary, and will help address CALFED's Priority 1 on factors to consider when allocating environmental water.

A second CALFED Preferred Program is Ecosystem Restoration. A component of ecosystem restoration that is emphasized by Priority Topic 4 is assessing the effects of future activities on Delta Habitat. Future plans for the estuary include restoration of wetlands. Wetlands are known sites of MeHg production (Grigal 2002) and reactive DOC production (Bossio et al. 2006). This research will benefit regulators by determining how the combination of those two factors could affect MeHg to phytoplankton.

This research will also help the San Francisco Bay Regional Water Quality Control Board. One of the main challenges faced by that agency in trying to implement the mercury Total Maximum Daily Load (TMDL) is that it is difficult to reduce mercury loads because there is a lot of mercury already in the system from legacy mining sources (personal communication, Richard Looker, Water Resource Control Engineer at the San Francisco Bay Regional Water Quality Control Board). Therefore, the water board needs information on how mercury is taken up the food web to develop effective management strategies.

Benefits to Fellow, Research Mentor, and Community Mentor

The fellow, research mentor, and community mentor will benefit from the exchange of methods and expertise that will occur during this interdisciplinary project. As the fellow, I will contribute my expertise on measuring trace metals, including mercury, and developing statistical models to describe metal concentrations. The research mentor, Dr. Nicholas Fisher, will provide his laboratory and techniques for radiotracer methods. The community mentor, Dr. Brian Bergamaschi, will serve as our DOM expert and provide the DOM isolates. Together, we will be able to complete a project that none of us could tackle on our own.

The research will also be complimentary to our previous projects. For example, Dr. Fisher has previously looked at MeHg and Hg(II) bioavailability to phytoplankton cultured in water from Franks Tract and the Cosumnes River (Pickhardt and Fisher in

press). Unfortunately, that work was only able to look at concentrations, not composition of DOM. Similarly, Dr. Bergamaschi has an on-going interest in the nutritional value of DOM to the food web and this work will complement those studies. Finally, as the fellow, this research will enable me to build upon my past studies of metal cycling during a phytoplankton bloom (Luengen in prep.; Luengen et al. in press). Furthermore, I will learn new techniques that will build upon my interdisciplinary background.

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Figure 1. Proposed sites for testing the hypothesis that DOM quality affects MeHg uptake to phytoplankton.
Map courtesy of CALFED Science Fellow Program (http://www-csgc.ucsd.edu/EDUCATION/CALFED/CALFEDpdf/AppxB_BayDeltaSystMap1_A.pdf

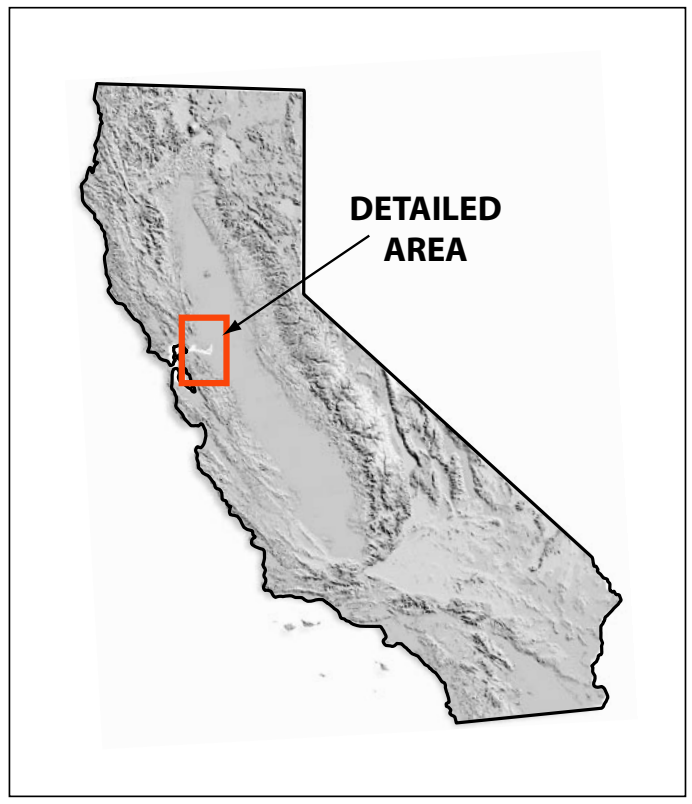

Figure 1

3) Budget and Budget Justification

The budget includes money in all years for travel between the community mentor in Sacramento and the research mentor on Long Island. Because this proposal involves sampling in the San Francisco Bay estuary, analyzing DOM in Sacramento, and employing laboratory techniques that require the special facilities of the research mentor, whose lab is equipped to handle radioactivity, a fair amount of travel will be required to make this collaboration possible. The budget reflects those anticipated travel expenses.

In the first year, the budget also includes money for a Tekran instrument that will be used to make mercury measurements. Money for bottles and reagents for that system is included. Some bottles and components must be purchased in the first year to allow adequate time to set-up the system before field sampling in the San Joaquin River begins in the second year. I will purchase a laptop during the first year of this study that will be used for the duration of the work and will enable me to go back and forth between the two labs.

The second and third year budgets also include money for additional sampling supplies, which will be primarily reagents and bottles. Into the third year, reagents will be needed to analyze the samples for MeHg and Hg(II).

The budget also includes money to attend and register for conferences in all years, which will be a critical part of presenting this research and learning about current work conducted by others. The international travel budgeted in the third year is for the Ninth International Conference on Mercury as a Global Pollutant which will be held in Guiyang, China in June 2009. I also plan to present results at meetings of the American Society for Limnology and Oceanography and State of the Estuary conferences.

FISCAL YEAR Jan. 1, 2007-Dec. 31, 2007

PROJECT NUMBER

NAME OF MENTOR Peter Hernes/ Brian Bergamaschi

INSTITUTION University of California at Davis

NAME OF FELLOW Allison Luengen

			CALFED FUNDS
A. EXPENDABLE SUPPLIES AND EQUIPMENT			
1. Reagents			500
2. Misc lab supplies			1,000
3. Computer			2,000
4. Bottles			500
5.			
		TOTAL SUPPLIES	4,000
B. PERMANENT EQUIPMENT			
1. Tekran instrument			7,650
2.			
3.			
4.			
5.			
		TOTAL EQUIPMENT	7,650
C. TRAVEL			
1. DOMESTIC-U.S. AND ITS POSSESSIONS			3,500
2. INTERNATIONAL (INCLUDING CANADA AND MEXICO)			
		TOTAL TRAVEL	3,500
D. PUBLICATION AND DOCUMENTATION COSTS		TOTAL PUB COSTS	
E. OTHER COSTS			
1. Fellowship Stipend			45,000
2. ASLO membership and conference registration			430
3.			
4.			
5.			
6.			
7.			
8.			
		TOTAL OTHER COSTS	45,430
F. TOTAL DIRECT COSTS	*(A THROUGH E)*	TOTAL DIRECT COSTS	60,580
G. INDIRECT COSTS			
ON CAMPUS	OF	Base: 7,930	
OFF CAMPUS	OF		
		TOTAL INDIRECT COSTS	1,983
H. TOTAL COSTS		TOTAL COSTS	62,563

DATE:

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FISCAL YEAR Jan. 1, 2008-Dec. 31, 2008

PROJECT NUMBER

NAME OF MENTOR Peter Hernes/ Brian Bergamaschi

INSTITUTION University of California at Davis

NAME OF FELLOW Allison Luengen

			CALFED FUNDS
A. EXPENDABLE SUPPLIES AND EQUIPMENT			
1. Reagents			1,000
2. Misc lab supplies			5,000
3. Computer			500
4. Bottles			2,000
5. Office supplies			100
		TOTAL SUPPLIES	8,600
B. PERMANENT EQUIPMENT			
1.			
2.			
3.			
4.			
5.			
		TOTAL EQUIPMENT	0
C. TRAVEL			
1. DOMESTIC-U.S. AND ITS POSSESSIONS			6,000
2. INTERNATIONAL (INCLUDING CANADA AND MEXICO)			
		TOTAL TRAVEL	6,000
D. PUBLICATION AND DOCUMENTATION COSTS		TOTAL PUB COSTS	500
E. OTHER COSTS			
1. Fellowship Stipend			45,000
2. ASLO membership and conference registration			430
3.			
4.			
5.			
6.			
7.			
8.			
		TOTAL OTHER COSTS	45,430
F. TOTAL DIRECT COSTS	*(A THROUGH E)*	TOTAL DIRECT COSTS	60,530
G. INDIRECT COSTS			
ON CAMPUS	OF	Base: 15,530	
OFF CAMPUS	OF		
		TOTAL INDIRECT COSTS	3,883
H. TOTAL COSTS		TOTAL COSTS	64,413

DATE:

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FISCAL YEAR Jan. 1, 2009-Dec. 31, 2009

PROJECT NUMBER

NAME OF MENTOR Peter Hernes/ Brian Bergamaschi

INSTITUTION University of California at Davis

NAME OF FELLOW Allison Luengen

			CALFED FUNDS
A. EXPENDABLE SUPPLIES AND EQUIPMENT			
1. Reagents			1,000
2. Misc lab supplies			2,000
3. Computer supplies			500
4.			
5.			
		TOTAL SUPPLIES	3,500
B. PERMANENT EQUIPMENT			
1.			
2.			
3.			
4.			
5.			
		TOTAL EQUIPMENT	0
C. TRAVEL			
1. DOMESTIC-U.S. AND ITS POSSESSIONS			6,000
2. INTERNATIONAL (INCLUDING CANADA AND MEXICO)			4,000
		TOTAL TRAVEL	10,000
D. PUBLICATION AND DOCUMENTATION COSTS		TOTAL PUB COSTS	1,000
E. OTHER COSTS			
1. Fellowship Stipend			45,000
2. ASLO membership and conference registration			450
3. World mercury conference registration			620
4.			
5.			
6.			
7.			
8.			
		TOTAL OTHER COSTS	46,070
F. TOTAL DIRECT COSTS	*(A THROUGH E)*	TOTAL DIRECT COSTS	60,570
G. INDIRECT COSTS			
ON CAMPUS	OF	Base: 15,570	
OFF CAMPUS	OF		
		TOTAL INDIRECT COSTS	3,893
H. TOTAL COSTS		TOTAL COSTS	64,463

DATE:

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Summary: Jan. 1, 2007-Dec. 31, 2009

PROJECT NUMBER

NAME OF MENTOR Peter Hernes/ Brian Bergamaschi

INSTITUTION University of California at Davis

NAME OF FELLOW Allison Luengen

		Year 1	Year 2	Year 3	Total
A. EXPENDABLE SUPPLIES AND EQUIPMENT					
1. Reagents		500	1,000	1,000	2,500
2. Misc lab supplies		1,000	5,000	2,000	8,000
3. Computer supplies		2,000	500	500	3,000
4. Bottles		500	2,000		2,500
5. Office supplies			100		100
	TOTAL SUPPLIES	4,000	8,600	3,500	16,100
B. PERMANENT EQUIPMENT					
1. Tekran Instrument		7,650			7,650
2.					
3.					
4.					
5.					
	TOTAL EQUIPMENT	7,650			7,650
C. TRAVEL					
1. DOMESTIC-U.S. AND ITS POSSESSIONS		3,500	6,000	6,000	15,500
2. INTERNATIONAL (INCLUDING CANADA AND MEXICO)				4,000	4,000
	TOTAL TRAVEL	3,500	6,000	10,000	19,500
D. PUBLICATION AND DOCUMENTATION COSTS	TOTAL PUB COSTS		500	1,000	1,500
E. OTHER COSTS					
1. Fellowship Stipend		45,000	45,000	45,000	135,000
2. ASLO membership and conference registration		430	430	450	1,310
3. World mercury conference registration				620	620.
4.					
5.					
6.					
7.					
8.					
	TOTAL OTHER COSTS	45,430	45,430	46,070	136,930
F. TOTAL DIRECT COSTS *(A THROUGH E)*	TOTAL DIRECT COSTS	60,580	60,530	60,570	181,680
G. INDIRECT COSTS					
ON CAMPUS _____ OF					
OFF CAMPUS _____ OF					
	TOTAL INDIRECT COSTS	1,983	3,883	3,893	9,759
H. TOTAL COSTS	TOTAL COSTS	62,563	64,413	64,463	191,439

DATE:

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4) Explanation of how the proposed research links to the CALFED program

Part of CALFED's mission is to restore the ecological health and protect beneficial uses of the Bay Delta System. The estuary's ecological health is currently threatened by high mercury concentrations, which impair the reproductive success of bird species, including the endangered Clapper Rail. Beneficial uses of the estuary, such as fishing, are also adversely affected by the high mercury concentrations. However, the factors that control mercury accumulation in the pisciverous food chain are poorly understood, making it difficult for regulators to determine what actions should be taken to reduce mercury accumulation. This proposal suggests that regulators may be able to control the composition of dissolved organic matter (DOM) to reduce mercury accumulation to phytoplankton, and thus to the food chain.

The first component of this research would investigate how DOM quality at different sites affects mercury bioavailability to phytoplankton. The linkage between DOM quality and algal uptake of mercury might explain why organisms from the Central Delta have low mercury concentrations relative to those from the tributaries and Suisun Bay. By developing a spatially-explicit model on how DOM and mercury accumulation are linked, this research would help regulators anticipate which sites and conditions (including seasonal changes) are likely to transfer mercury to the food chain.

The second component of this research will help regulators determine how they could manage the composition of DOM at those sites to decrease mercury bioavailability. For example, if we find that the mercury accumulated by phytoplankton is preferentially associated with organic matter from animal wastes, as opposed to agricultural run-off, regulators could focus DOM reduction efforts appropriately. This benefit addresses CALFED's priority goal on environmental water by helping regulators evaluate the importance of water quality factors when deciding the type and quality of water that will be released to different locations in the estuary.

Finally, the last component of this research, the biogeochemical model, would provide regulators with a critical tool for determining how changes in Delta configuration and land use will affect mercury accumulation. This outcome is directly relevant to the CALFED priority goal on habitat and response to change. For example, one of the proposed changes in the Delta is restoration of 10,000 ha of agricultural areas to wetlands. By determining how DOM produced in wetlands will affect MeHg bioavailability to phytoplankton, this research will provide information on how the quality of Delta habitat will be affected by future scenarios. The impacts of other scenarios, such as increased DOM from wastewater treatment plant inputs as a result of population growth could also be assessed using this model.

In conclusion, this research will help address the CALFED priority goals on environmental water and habitat availability by helping regulators use DOM composition as a tool to allocate environmental water and evaluate the potential for mercury accumulation. The overall goal is to predict and minimize conditions that increase mercury bioavailability to phytoplankton.

5) Personal Statement

My goal is an academic career at a leading research university, where I will be able to contribute to our understanding of metal bioavailability and cycling in estuaries. Because estuaries are interfaces where rivers meet the sea, they are unusually complicated systems, and the additional experience provided by this postdoctoral position would help me succeed in my field. Specifically, this postdoctoral position would expand my expertise to include the composition of dissolved organic matter and radiotracer methods. This unique, interdisciplinary combination would allow me to address one of the pressing questions in my field: what processes control uptake of methyl mercury to phytoplankton at the base of the food chain? To conduct this research, I will draw upon my previous experiences conducting multidisciplinary research, modifying analytical techniques, developing statistical models, and presenting my results to others.

I am currently finishing my Ph.D. research at the University of California on trace metal biogeochemistry in the San Francisco Bay estuary. The research addresses the combined environmental impacts of nutrient enrichment and metal contamination in the estuary, using interdisciplinary methods. I collaborated with a phytoplankton ecologist at the USGS (Dr. James Cloern) to follow a phytoplankton bloom, applied trace metal clean techniques to collect and analyze water samples, and then developed statistical models to analyze the complex data set. The results demonstrated that nutrient-enriched phytoplankton blooms in South San Francisco Bay affect metal cycling. This experience analyzing complex environmental data will help me conduct the interdisciplinary research that I have proposed. Moreover, it demonstrates that I enjoy working with people from multiple agencies and will be able to coordinate with my research mentor, my community mentor, and CALFED agencies.

As a result of this Ph.D. research in Environmental Toxicology and my M.S. research in Marine Sciences, I have also learned a number of analytical techniques that will help me succeed as a postdoctoral researcher. As a graduate student, I developed a procedure for measuring methyl mercury in our laboratory. To develop that procedure, I initiated collaboration with Nicolas Bloom, Senior Research Scientist at Studio Geochimica, and wrote a proposal to work with him in Seattle. Bloom is arguably the world's leading mercury analyst. During the process of adapting his method for our lab, I trained an undergraduate student. I then worked closely with her to analyze water samples for methyl mercury by distillation and detection by cold vapor atomic fluorescence spectroscopy (CVAFS). As part of my collaboration with Bloom, I also worked with him to measure total mercury in water using bubblers and CVAFS in his lab. We compared those results with samples that I measured in our lab using a Tekran 2600. As a result of these experiences, I am familiar with instrumental methods that I will need to make the mercury measurements proposed for this research.

I also have experience developing methods from my M.S. research on immune responses of blue mussels at contaminated sites in San Francisco Bay. I began that research by using a protocol that damaged the hemocytes, or mussel immune cells, with which I was working. I rapidly created a new method, demonstrating my ability to quickly grasp and modify procedures. This experience and others developing methods will be valuable as I learn and modify procedures for measuring dissolved organic matter.

My research proposal also calls for development of a biogeochemical model, which will build on the statistical methods I developed for my M.S. and Ph.D. research. Both those projects integrated statistical methods not traditionally used in toxicology or oceanography. For example, my Ph.D. research employed PCA to reduce a complicated data set to factors that described the growth of a phytoplankton bloom, the amount of material available for sorption of metals, and the decay of that bloom. By using this technique, I was able to create a more comprehensive picture of the system than I could have achieved with more common methods, such as looking at a regression with chlorophyll-a. This statistical experience will be invaluable for analyzing the complex set of parameters that I expect to gather during sampling of the San Joaquin River.

My M.S. and Ph.D. research experience gives me the scientific background necessary to complete, present, and publish my proposed studies. My successful completion and publication of both my M.S. research in *Marine Environmental Toxicology* and the first chapter of my Ph.D. thesis in *Limnology and Oceanography* demonstrates my ability to complete a major academic work in a planned time frame. I have also been recognized for my research presentations at scientific meetings; I was awarded Best Student Platform Presentation at the May 2005 Northern California Society of Environmental Toxicology and Chemistry (NorCal SETAC) Meeting.

In addition to presenting my scientific research through meetings and papers, I plan to interface with regulators and stakeholders about the results of that research. Informing these groups of my results is particularly important because my postdoctoral work is directly relevant to CALFED's goal of determining how drivers, such as contaminants, affect habitat availability. This work is also relevant to the development of a Total Daily Maximum Load (TMDL) for mercury in the estuary.

Presenting my work to regulatory agencies will build on my experience as a research associate for the San Francisco Estuary Institute (SFEI), the non-government agency charged with monitoring San Francisco Bay, and my work in the California State Assembly. My work for SFEI allowed me to interface with scientists, regulators, and stakeholders, an interest that I have continued to develop. For example, after completion of my M.S. research, I presented those findings to SFEI as a potential new bioindicator for assessing contaminant effects. I have also had the opportunity to analyze environmental public policy as an intern in the California State Assembly. That experience increased my appreciation for the multiple viewpoints that were integrated into environmental public policy.

By interacting with these groups, I will be able to sharpen my teaching skills, an aspect that will help me with my career goal of teaching and researching at a university. One of the reasons that I have chosen a career in this field is that I enjoy working on issues that are relevant to the community, and thus to the students. This postdoctoral position will allow me to advance my career by researching a topic that is exciting to me and will simultaneously benefit CALFED by helping unravel the mystery of how mercury accumulates in phytoplankton at the base of the food chain.

6) Curriculum vitae of the applicant

Allison Luengen
Department of Environmental Toxicology
University of California at Santa Cruz
Santa Cruz, CA 95064
(831) 459-2088
allisonl@ucsc.edu

EDUCATION

PH.D., ENVIRONMENTAL TOXICOLOGY December 2006
(expected)
UNIVERSITY OF CALIFORNIA AT SANTA CRUZ

Dissertation:
Investigating the spring bloom in San Francisco Bay: Links between metal cycling, mercury speciation, nutrient levels, and phytoplankton species composition
My research, under the direction of Professor Russell Flegal, demonstrated that nutrient-enriched phytoplankton blooms in San Francisco Bay affect cycling of metals. For example, the spring 2003 bloom depleted some metals (e.g. Ni) from the water, and blooms could entrain those metals within the estuary. I also showed that decay of the bloom is an important period for remobilization of metals from sediments.

M.S., MARINE SCIENCES
2001
UNIVERSITY OF CALIFORNIA AT SANTA CRUZ

Thesis:
Mussel immune responses as biomonitors of stress in San Francisco Bay
I developed a new method for assaying phagocytosis in mussels and showed that contaminant exposure has measurable sublethal effects in mussels from the southern reach of the bay.

B.A., INTEGRATIVE BIOLOGY
1998
UNIVERSITY OF CALIFORNIA AT BERKELEY

Honors in Integrative Biology
Distinction in general scholarship

HONORS AND AWARDS

2005	Dissertation-Year Fellowship Award
2005	University of California at Santa Cruz Ocean Sciences Department Outstanding Student Achievement Award
2005	Northern California Society of Environmental Toxicology and Chemistry (NorCal SETAC) Best Student Platform Presentation
2005	Center for the Dynamics and Evolution of the Land-Sea Interface (CDELSI) Travel Award
2005	STEPS Institute for Innovation in Environmental Research Gradate Research Award
2005	CDELSI Ocean Health and Environmental Change Fellowship Honorable Mention
2004	NorCal SETAC Scholarship for best research proposal
2002	Friends of the Long Marine Lab Student Research and Education Award
2001	Western Association of Graduate Studies Distinguished Master's Thesis Finalist
2000	University of California at Santa Cruz Dean's Fellowship for outstanding academics
2000	National Shellfish Association Student Endowment Award

1999 Achievement Rewards for College Scientists (ARCS) Foundation Scholarship
1999 Friends of the Long Marine Lab Student Research and Education Award
1998 Friends of the Long Marine Lab Student Research and Education Award
1997 Morris Udall Environmental Public Policy Scholarship
1997 University of California at Berkeley Wilcox Family Alumni Leadership Scholarship
1996 University of California at Berkeley Mary Johnson Alumni Leadership Scholarship
1995 University of California at Berkeley Alumni Leadership Scholarship for leadership and service
1994 University of California at Berkeley Alumni Leadership Scholarship for leadership and service

FUNDED GRANT PROPOSALS

2005-2007 Metal cycling and bioavailability during phytoplankton blooms in South San Francisco Bay, University of California Water Resources Center.

PUBLICATIONS

Luengen A. C., Raimondi P. T., and Flegal A. R. (in press) Contrasting biogeochemistry of six trace metals during the rise and decay of a spring phytoplankton bloom in San Francisco Bay. *Limnology and Oceanography*.

Luengen A. C., Friedman C. S., Raimondi P. T., and Flegal A. R. (2004) Evaluation of mussel immune responses as indicators of contamination in San Francisco Bay. *Marine Environmental Research* 57, 197-212.

Luengen A. C. (2001) Mussel immune responses as biomonitors of stress in San Francisco Bay. Masters of Science Thesis, University of California at Santa Cruz.

MANUSCRIPTS IN PREPARATION

Luengen A. C., Bloom N. S., and Flegal A. R. Interaction between nutrients, phytoplankton blooms, and mercury concentrations in San Francisco Bay. To be submitted to *Limnology and Oceanography.*

Luengen A. C., Raimondi P. T., and Flegal A. R. Phytoplankton biological species composition and metal uptake. To be submitted to *Marine Ecology Progress Series.*

PRESENTATIONS AT SCIENTIFIC MEETINGS

Luengen A. C., Bloom, N. S., and Flegal A. R. (2006). Mercury cycling during a spring phytoplankton bloom in San Francisco Bay (poster). Eighth International Conference on Mercury as a Global Pollutant. Madison, Wisconsin, August 6-11, 2006.

Luengen A. C. and Flegal A. R. (2006). Depletion of methyl mercury during a spring phytoplankton bloom in South San Francisco Bay (poster). Northern California Chapter of the Society of Toxicology Spring Meeting, Half-Moon Bay, California, April 28-29, 2006.

Luengen A. C. and Flegal A. R. (2006). Interaction between nutrients, phytoplankton blooms, and mercury concentrations in San Francisco Bay (poster). American Society of Limnology and Oceanography 2006 Ocean Sciences Meeting. Honolulu, Hawaii, February 20-25, 2006.

Luengen A. C. and Flegal A. R. (2005). Contrasting biogeochemistry of six trace metals during a spring phytoplankton bloom in San Francisco Bay (poster). Seventh Biennial State of the San Francisco Estuary Conference, Oakland, California, October 4-6, 2005.

Luengen A. C. and Flegal A. R. (2005). Methyl mercury concentrations during a spring phytoplankton bloom in San Francisco Bay (oral presentation). Northern California Regional Chapter of the Society of Environmental Toxicology and Chemistry, Berkeley, California, May 3-4, 2005.

Luengen A. C. and Flegal A. R. (2005). Pronounced variations in nutrients and trace metals during a spring phytoplankton bloom in San Francisco Bay (oral presentation). American Society of Limnology and Oceanography 2005 Aquatic Sciences Meeting, Salt Lake City, Utah, February 20-25, 2005.

Luengen A. C. and Flegal A. R. (2004). Draw-down of metals during a spring phytoplankton bloom in South San Francisco Bay (poster). American Geophysical Union Fall 2004 Meeting, San Francisco, California, December 13-17, 2004.

Luengen A. C. and Flegal A. R. (2004). Mercury cycling during a spring bloom (poster). Northern California Society of Environmental Toxicology and Chemistry 14th Annual Meeting, Davis, California, May 11-12, 2004.

Luengen A. C. and Flegal A. R. (2003). Sampling mercury during a phytoplankton bloom in South San Francisco Bay (poster). University of California Toxic Substances Research and Teaching Program 16th Annual Research Symposium, Oakland, California, April 25-26, 2003.

Luengen A. C., Friedman C. S., and Flegal A. R (2000). Mussel immune systems as biomarkers of contaminant exposure in San Francisco Bay, California (oral presentation). 11th International Conference on Heavy Metals in the Environment, Ann Arbor, Michigan, August 6-10, 2000.

Luengen A. C., Friedman C. S., and Flegal A. R (2000). Measurement and development of a new technique to assess immune system responses of mussels following contaminant exposure in San Francisco Bay, CA (poster). University of California Toxic Substances Research and Teaching Program 13th Annual Research Symposium, San Diego, California, April 28 - 29, 2000.

Luengen A. C., Friedman C. S., and Flegal A. R (2000). Immune responses of two species of mussels (*Mytilus californianus* and *Mytilus galloprovincialis*/*trossulus* hybrid) to pollutants in San Francisco Bay, CA (oral presentation). 92nd Annual National Shellfisheries Association Meeting, Seattle, Washington, March 19-23, 2000.

Luengen A. C. and Flegal A. R. (1999). Effects of copper on bivalve immune systems (poster). University of California Toxic Substances Research and Teaching Program 12th Annual Research Symposium, Santa Barbara, California, April 9-10, 1999.

WORK EXPERIENCE

COSMOS PROGRAM INSTRUCTOR 2002 - 2005
UNIVERSITY OF CALIFORNIA AT SANTA CRUZ
Planned and instructed environmental toxicology module for the California State Summer School for Mathematics and Science (COSMOS). Created a unique field-based curriculum to teach high school students water quality analyses and data interpretation at a local lagoon. Integrated scientific writing through student essays on environmental impacts at that site. Coordinated with Teacher Fellow and Chemistry Instructors to develop and guide student final projects.

GRADUATE STUDENT RESEARCHER 1998 - 2005
UNIVERSITY OF CALIFORNIA AT SANTA CRUZ
Developed method for measuring methyl mercury in water in our lab, based on collaboration with leading expert Nicolas Bloom, Senior Research Scientist at Studio Geochimica. Trained student staff on that method and wrote protocol. Ran lab storm water sampling project and analyzed those samples for total mercury. Collected trace metal clean water samples on cruises in San Francisco Bay.

TEACHING ASSISTANT FOR AQUATIC TOXICOLOGY Fall 2001, Fall 2004
DEPARTMENT OF ENVIRONMENTAL TOXICOLOGY, UNIVERSITY OF CALIFORNIA AT SANTA CRUZ
Created new material to instruct students on reading and writing scientific papers. Advised students on how to select topics, find scientific journal articles, and write scientific papers. Introduced students to quantitative calculations of contaminant concentrations and wrote homework set on that topic.

TEACHING ASSISTANT FOR ENVIRONMENTAL STATISTICAL ANALYSIS Fall 2002
DEPARTMENT OF ENVIRONMENTAL TOXICOLOGY, UNIVERSITY OF CALIFORNIA AT SANTA CRUZ
Created innovative discussion material, wrote problem sets and handouts, and led weekly discussion section. Advised students on statistical methods for final projects.

TEACHING ASSISTANT FOR THE OCEANS Spring 1999
OCEAN SCIENCES DEPARTMENT, UNIVERSITY OF CALIFORNIA AT SANTA CRUZ
Developed and taught laboratory sections and discussions. Gave guest lecture on marine pollution.

RESEARCH ASSOCIATE June - September 1998
SAN FRANCISCO ESTUARY INSTITUTE
Provided interpretation and analyses of scientific data on contaminants in the San Francisco Bay to key parties, including the public, governmental regulators, and private dischargers. Presented those analyses though print media, annual monitoring report, and oral presentations to supervisors.

INTERN FOR ASSEMBLYWOMAN DENISE DUCHENY Summer 1996
CALIFORNIA STATE ASSEMBLY
Researched and wrote policy analyses for California State Assembly members on environmental issues appearing before the Water, Parks, and Wildlife Committee. Bills appearing before the committee included legislation to reduce criminal liability for dumping pollutants into state waters.

ACADEMIC AND COMMUNITY SERVICE

2005- Present Internal Vice President of the Graduate Student Association
University of California at Santa Cruz
- Collaborated with Senior Administration to involve graduate students in diversity programs, including Chancellor's Inaugural Diversity Symposium
- Negotiated campus policies on transportation, ethical treatment of graduate students, and health care with Senior Administration, Chancellor, and Executive Vice Chancellor

2004- 2005 Secretary of the Graduate Student Association
University of California at Santa Cruz
- Revised Academic Appeals Process to ensure the protection of graduate students, particularly underrepresented groups

2002- 2004 Treasurer of the Graduate Student Association
University of California at Santa Cruz
- Collaborated with Central Business Operations to authorize and reconcile expenditures. Reported budget status to Graduate Student Association Council and oversaw funds awarded by Council

2001- Present Chair of Health Insurance Committee of the Graduate Student Association
University of California at Santa Cruz
- Negotiated Graduate Student Health Insurance Plan, including benefits, terms, and conditions

1997- 1998 President of Alumni Scholars Club
University of California at Berkeley
- Directed student group focused on service to the university and community

1994- 1998 Founding member of Eggster
University of California at Berkeley
- Created service event to bring disadvantaged and disabled students to the Berkeley campus

PROFESSIONAL AFFILIATIONS

2005- Present Member, The Oceanography Society
2004- Present Member, American Geophysical Union
2004- Present Member, The American Society of Limnology and Oceanography
2004- Present Member, Northern California Society of Environmental Toxicology and Chemistry

7) Plan for collaborating with community mentors

The community mentor for this project, Dr. Brian Bergamaschi, United States Geological Survey, will be an integral part of this project. His letter of support is included in this application. I will work with Dr. Bergamaschi to take advantage of his knowledge on DOM composition, his analytical and field equipment, and his relevant contacts on water quality in the Delta.

First, working with Dr. Bergamaschi will help me tie my research into the larger context of DOM composition and quality in the Delta. Dr. Bergamaschi and coworkers have already analyzed DOM composition and gathered isolates of DOM from various sites in the Delta. I will use that background information and some of those isolates to begin my the first part of my research on how DOM composition affects MeHg uptake to phytoplankton.

During the second and third years of this postdoctoral fellowship, I will collaborate extensively with Dr. Bergamaschi to conduct field sampling in conjunction with his project on nitrate and organic carbon inputs into the San Joaquin River. Both of us will benefit because our joint effort will enable us to conduct additional analyses on DOM characteristics. I will also be able to use some of the parameters collected by Dr. Bergamaschi for the final part of my project, which will be the development of a biogeochemical model to describe factors controlling mercury uptake to phytoplankton.

Finally, I plan to work with Dr. Bergamaschi to make sure that I identify key agencies where I should present my research. Because Dr. Bergamaschi has previously worked on water quality in the Delta, I will be able to take advantage of his contacts in that area to ensure that my research reaches the agencies that will most benefit from it. Furthermore, I will be able to draw upon my own experience working for the San Francisco Estuary Institute and connecting with people in the California Regional Water Quality Control Board to help me present my results in a format that will be readily accessible to regulators.

Brian A. Bergamaschi, Ph.D.
United States Geological Survey
Water Resources Division
California State University, Placer Hall, 6000 J Street
Sacramento, California 95819-6129
(916) 278-3053 Fax (916) 278-3071 bbergama@usgs.gov

CALFED Science Fellows Program
California Sea Grant College Program
University of California, San Diego
9500 Gilman Drive Dept. 0232
San Diego, CA 92093-0232

Dear CALFED Science Fellows Program,

This letter is in support of Allison Luengen's proposal entitled "MERCURY AND DISSOLVED ORGANIC CARBON INTERACTIONS: EFFECTS ON MERCURY BIOAVAILABILITY IN THE SAN FRANCISCO BAY DELTA." This proposal represents an area of essential interdisciplinary study and begins to fill a major gap in our understanding of mercury bioaccumulation in the Sacramento-San Joaquin Delta and San Francisco Bay Estuary. I hope to be working with Ms. Luengen on this important project.

This proposal explores an important pathway for mercury bioaccumulation in the Delta and Estuary, and certainly has ramifications for other areas as it explores fundamental processes of mercury accumulation in algae. Most importantly, the results of the proposed research will inform CALFED managers about the likely environmental consequences of proposed changes in Delta hydrodynamics and land use within the Delta.

I would be pleased to host Ms. Luengen in my lab group and agree to provide the additional support necessary under this proposal, though it may be more practical for her to work in Dr. Fisher's laboratory. She will certainly be working closely with us both.

This work compliments my current CALFED-funded research into the cycling of mercury species in tidal systems in the San Francisco Bay Estuary, and many of the chemical analyses mentioned in this proposal will be supported by my other proposals.

Please contact me if you need any additional information.

Sincerely,

Brian A. Bergamaschi

CALFED SCIENCE FELLOWS PROGRAM

In cooperation with the
California Sea Grant College Program

PROJECT SUMMARY FORM

Project Number:	**Revision Date:**
Project Title: Mercury and dissolved organic carbon interactions: Effects on mercury bioavailability in the San Francisco Bay Delta	**Initiation Date:**
	Completion Date:

Mentor/Principal Investigator: Dr. Nicholas S. Fisher, Distinguished Professor

Affiliation: State University of New York, Stony Brook

Fellow: Allison Luengen

Affiliation: University of California, Santa Cruz

CALFED Funds:	**Last Year's CALFED Funds:**

OBJECTIVES:

We would like to establish which chemical parameters govern mercury uptake to phytoplankton in the San Francisco Bay estuary and Delta. Previous research has indicated that a key parameter that controls mercury uptake to phytoplankton is dissolved organic matter (DOM), but the mechanism remains unclear. One goal of this work is to investigate the hypothesis that phytoplankton are deliberately acquiring DOM and their active accumulation of methyl mercury (MeHg) is an accidental by-product of that process due to the association of DOM and MeHg. By researching how MeHg is accumulated in phytoplankton at the base of the food chain, this proposal aims to help regulators understand what actions could reduce MeHg entry to the food chain. Accordingly, this research will help fulfill CALFED's goal of understanding the drivers that affect habitat quality in the estuary. Specifically, this proposed research would:

(1) assess how the bioavailability of mercury to phytoplankton is affected by DOM composition. DOM of varying composition, isolated from a number of sites in the Delta, will be used culture phytoplankton. Radiolabeled MeHg and inorganic mercury (Hg(II)) will then be added to those cultures and phytoplankton uptake of MeHg and inorganic mercury (Hg(II)) will be measured. By determining how DOM quality affects MeHg and Hg(II) uptake to phytoplankton, this component of the research will shed light on the mechanism of mercury uptake to phytoplankton.

(2) test the association between MeHg and Hg(II), phytoplankton, and DOM quality by lagrangian sampling in San Joaquin River. This component of the research will help to establish how water chemistry, including the composition of the DOM, affects mercury transport and bioavailability to phytoplankton.

(3) develop a model to predict the processes controlling MeHg uptake to phytoplankton and thus to the food chain. The model with synthesize results from the previous two sections and serve as a tool to help regulators reduce mercury entry to the food chain.

RATIONALE:

There are consumption advisories for several species of fish is the San Francisco Bay and Delta because of elevated mercury levels, yet the way mercury enters the pisciverous foodchain remains unknown. Presumably mercury exposure occurs and mercury is bioaccumulated by the same trophic pathways that supply the energetic requiremenents of fish- i.e. through association with with phytoplankton. Phytoplankton concentrate MeHg by a factor of 10^5, making them the largest single step in MeHg bioaccumulation. However, uptake of MeHg to phytoplankton is affected by the chemistry of the surrounding waters. I propose to examine the chemical parameters that affect MeHg association with phytoplankton and develop a model for prediction of MeHg association with phytoplankton useful for understanding MeHg occurrence in the Delta and Estuary. This model will be instrumental for ecosystem managers to address prospective effects of land use changes and wetland restorations.

PROJECT SUMMARY FORM (continued)

Mentor/Principal Investigator: Dr. Nicholas S. Fisher, Distinguished Professor

Fellow: Allison Luengen

METHODOLOGY:

The first phase of this research will use radiotracer methods to look at the bioavailability of mercury to phytoplankton cultured in DOM isolates of differing composition. Radioactive $CH_3{}^{203}HgCl$ and $^{203}Hg^{2+}$ will be added to the cultures and uptake to phytoplankton will be measured daily, using methods previously developed in the Fisher lab (Pickhardt and Fisher, in press). We expect that the quality of the DOM will affect the amount of $CH_3{}^{203}HgCl$ accumulated by phytoplankton. These experiments will also be conducted with heat killed phytoplankton to allow us to calculate how much $CH_3{}^{203}HgCl$ is actively assimilated by live phytoplankton versus sorbed by passive processes.

The second phase of the research will employ a lagrangian sampling scheme to follow a water mass down the San Joaquin River and investigate the relationship between DOM composition, mercury speciation, and chlorophyll-a concentration. The DOM samples will be analyzed using standard methods in the Bergamaschi laboratory for DOM composition. Those DOM analyses will include DOC concentrations, POC concentrations, specific UV absorbance, florescence, and glutathione concentrations. Additional water samples, collected using trace metal clean techniques, will analyzed for MeHg and Hg_T. Concentrations of MeHg will be determined by distillation, aqueous phase ethylation, volatile organic trapping, and analyses by cold vapor atomic fluorescence spectrophotometry (CVAFS) (Bloom 1989; Horvat et al. 1993). Water samples for Hg_T will be analyzed using CVAFS following tin chloride reduction and two-stage gold amalgamation trapping (Bloom and Fitzgerald 1988; Gill and Fitzgerald 1987).

The last part of this research will use statistical methods to develop a biogeochemical model predicting the parameters that effect MeHg and Hg_T uptake to phytoplankton. We will use the statistical package Systat to complete these analyses. The model will be spatially explicit, based on our results from the first part of the study comparing MeHg and Hg(II) uptake to phytoplankton cultured in DOM from specific sites. We will compare our model with other data on mercury concentrations in water and organisms in the Delta.

ACCOMPLISHMENTS:

This research will help determine which factors control MeHg uptake to phytoplankton, which will be an important result for CALFED managers who trying to evaluate how changes in Delta land use could affect mercury concentrations and thus habitat quality. The results will include a spatially-explicit study on how DOM quality affects mercury accumulation to phytoplankton in the Delta. The association between DOM composition, mercury concentrations, and phytoplankton will then be modeled in the San Joaquin River to develop a comprehensive picture of the linkages between these parameters. The final result will be a comprehensive biogeochemical model describing mercury accumulation in phytoplankton in the estuary. The results will be published in four papers, presented at scientific meetings, and presented to regulators.

STONY BROOK UNIVERSITY/SUNY, STONY BROOK, N.Y. 11794 - 5000 (631) 632-8701
FAX (631) 632-8915

Dr. Allison Luengen
Department of Environmental Toxicology
University of California, Santa Cruz
Santa Cruz, CA

August 29, 2006

Dear Allison,

This letter is to register my strong support for your application for a CALFED postdoctoral position to pursue studies investigating the interactions of mercury with dissolved organic matter and the implications these interactions may have on affecting the bioaccumulation of this contaminant in the California Bay-Delta region. This work represents a natural extension of the work that we have been conducting–with CALFED support–where we have found that DOM can be shown to have a pronounced effect on the biological uptake of methylmercury by delta phytoplankton. We were quite surprised to learn that methylmercury uptake is both a passive AND active process in these cells. That is, there is an appreciable amount of passive sorption of methylmercury to cells, but living cells take up considerably more of this compound. They are actually expending energy in pumping this compound into the cells. The living cells pump the methylmercury into the cytoplasm of the cells, from which it can be assimilated in herbivorous grazers, whereas the sorbed methylmercury remains entirely on the cell surface, from which herbivores assimilate little. The presence of DOM actually enhances the active uptake of methylmercury in the phytoplankton cells, much to our surprise. In our recent publications, we have posited a number of possible explanations to account for these observations, but clearly considerably more work is needed to address this phenomenon.

Your proposal has outlined some of the obvious next steps that should be conducted, and it goes without saying that you would be very welcome to conduct as much of this research as you would like in our laboratory here at Stony Brook. To do so, I can make available our rather extensive algal culture collection, all necessary supplies and equipment (including for exploiting and analyzing gamma-emitting radioisotopes of mercury), technical assistance, and ample office space. I think that the teamwork you propose-yourself, Dr. Bergamaschi, and my group, would be exceptionally well suited to make rapid and important advances in this field. This work would combine Dr. Bergamaschi's analytical know-how in characterizing the dissolved organic material (not to mention his knowledge of the DOM of the delta region itself)–critical for this work–and your own expertise involving analytical chemistry of natural waters, focusing on trace metals, including mercury. We can provide advanced training in how to quantitatively assess the kinetics of mercury (and methylmercury) uptake and retention in

diverse aquatic organisms, including phytoplankton and diverse grazers of these cells. We can also provide assistance in constructing mercury bioaccumulation models using the kinetic parameters you determine in your experimental and field work.

The work you propose has potentially important implications for our understanding of mercury bioaccumulation in aquatic organisms, relevant to California's waters, but also to waters everywhere. Hence your findings would be greatly appreciated and read with interest by scientists working with natural waters from everywhere, not just the San Francisco Bay region. I believe these studies could have far-reaching implications for understanding the accumulation of mercury in aquatic food chains and consequently may influence the establishment of appropriate water quality criteria and even, possibly, remedial actions in some waters. I would be surprised if a fair number of first-rate publications did not emerge from this work.

Good luck with your proposal, and please keep me informed of its outcome.

Sincerely,

Nicholas Fisher
Distinguished Professor

N.S. Fisher
Marine Sciences Research Center
Stony Brook University
Stony Brook, NY 11794-5000

CURRICULUM VITAE

Name: Nicholas Seth Fisher

Present Position: Distinguished Professor
Marine Sciences Research Center
State University of New York
Stony Brook, New York 11794-5000

Date of Birth: 29 April 1949; New York, NY (U.S. citizen)

Marital Status: Married (1974); 2 children

Education:
Ph.D. Marine Biology, State University of New York, Stony Brook. 1974
B.A. Biology, Brandeis University, Waltham, Massachusetts. 1970
NSF Summer Student Fellow, Marine Biology Program, Humboldt State College, Arcata, California. 1965

Telephone: (631) 632-8649
FAX: (631) 632-3072
Email: nfisher@notes.cc.sunysb.edu

Positions Held:

2005 - present	Distinguished Professor, Marine Sciences Research Center, Stony Brook University
1991 - 2005	Professor, Marine Sciences Research Center, Stony Brook University
1998 - 2003	Associate Dean, Marine Sciences Research Center, Stony Brook University
1988 - 1991	Associate Professor, Marine Sciences Research Center, Stony Brook University
1985 - 1987	Oceanographer, Brookhaven National Laboratory, Upton, New York.
1980 - 1985	Research Scientist, International Laboratory of Marine Radioactivity, International Atomic Energy Agency, Monaco.
1977 - 1980	Senior Research Scientist, Marine Studies Group, Ministry for Conservation, Melbourne, Australia.
1974 - 1977	Postdoctoral Investigator, Chemistry Department, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts.
1970 - 1974	Teaching and Research Assistant, Division of Biological Sciences, State University of New York, Stony Brook.
1972 - 1973	Guest Student Investigator, Biology Department, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts.
2004 - 2005	John Simon Guggenheim Memorial Fellow

Awards/Distinctions:

1985 - present	Appointed as Marine Ecologist, Ecology Institute (Honorary Institute) Oldendorf-Luhe, Germany
1992 - 2005	Who's Who in America; Who's Who in the East, Who's Who in the World
2001 - present	Elected Chair, Marine Biogeochemistry Committee, International Commission for the Scientific Exploration of the Mediterranean (CIESM)
2004-2005	John Simon Guggenheim Memorial Fellowship
2005	Awarded State University of New York Distinguished Professorship
2006	Graduate School Dean's Award for Excellence in Graduate Mentoring

Member:

1983 - present:	American Men and Women in Science
1984 - present:	Editorial Advisory Board, Marine Ecology Progress Series
1993 - present:	Editorial Board, Marine Environmental Research
2003 - present:	IAEA Coordinated Research Group on the Bioaccumulation of Radionuclides
1992 - 2000:	International Union of Pure and Applied Chemistry Commission on Environmental Analytical Chemistry
1997-1998	COASTES Advisory Panel
1983 - 1985:	GESAMP Working Group on the Interchange of Pollutants between the Atmosphere and the Oceans
1975 - present:	American Society of Limnology and Oceanography
1974 - 1995:	American Phycological Society
1996 - present:	Society of Environmental Toxicology and Chemistry

Advisor for the following doctoral students (and where they first moved to):
Dr. Sarah Griscom (Harvard), Dr. Sharon Hook (Skidaway Inst. of Oceanography), Dr. Byeong-Gweon Lee (USGS, Menlo Park), Dr. John Reinfelder (MIT), Dr. Hudson Roditi (Globe Intl.), Dr. Ashaki Rouff (University of Illinois), Dr. Gillian Stewart (Queens College), Dr. Benjamin Twining (Yale), Dr. Wen-Xiong Wang (Univ. Science & Technology, Hong Kong)

Advisor for the following MS and Doctorate du Troisieme Cycle students (completed)
Donna Ashizawa, Michel Bohé, Douglas Frood, Gary Jones, Anthony Romeo, Maria Stepanova, Jean-Louis Teyssié, Randall Young

Advisor for the following doctoral graduate students (current):
Xi Chen, Jessica Dutton, Teresa Mathews, Zosia Turek, Catherine Vogel

Advisor for the following postdoctoral investigators: Stephen Baines, Poul Bjerregaard, Christian Gagnon, David Hutchins, Paul Pickhardt, Sayhan Topçuo™lu, Wen-Xiong Wang, Xiulin Wang

Research Interests:
biogeochemistry of metals in aquatic systems; contaminant-biota interactions; particle flux in aquatic systems; physiology and ecology of phytoplankton; phytoplankton-herbivore interactions; aquatic radioecology; aquatic pollution management strategies; aquatic toxicology.

Miscellaneous activities:
NSF Ocean Chemistry Review Panel (1988); New York State Sea Grant Review Panel (1989); NOAA National Status & Trends Review Panel (1990); NOAA Coastal Oceans Program Toxic Substances Review Panel (1990); New Hampshire Sea Grant Review Panel (2003); Marine Ecology Jury, Ecology Institute, Germany (1986, 1991, 1998); Expert Advisor for US Arctic Monitoring and Assessment Program (2000-present); New York Bight and Hudson Estuary Programs Toxic Substances Review Panel (1991); Advisory Panel to New York State Attorney General on PCBs in the environment (1976)

Consultant for:
U.S. Environmental Protection Agency; Brookhaven National Laboratory; International Atomic Energy Agency; National Association of Photographic Manufacturers; New York City Office of Management and Budget; Risø National Laboratory, Roskilde, Denmark; National Environmental Law Center; New York State Department of State; Fisher Island Conservancy; Applied Biomathematics; Hong Kong University of Science and Technology; Northeast Utilities; US District Court Maine (appointed Special Master of the Court)

University and departmental service (select activities):
Associate Dean, MSRC (1998-2003) and numerous activities associated with this position, Admissions Committee (8 years, chaired for 5 years), Executive Advisory Committee (7 years), Salary Analysis Task Force (chair), MSRC Graduate Programs Committee, MSRC Space Committee, MSRC Library Committee, MSRC liaison to University SPD Office, Strategic Planning Committee for Research, Committee for Coordinating Environmental Sciences at Stony Brook University, MSRC Colloquium coordinator (3 years), Distinguished Visiting Scholar Committee (chair, 4 years), Radiation Safety Officer, Member of Evaluation Team for Stony Brook-Brookhaven National Lab seed grants, Search Committees for molecular microbiologist (chair), environmental modeler (chair), physical oceanographer, marine ecologist, marine chemists (2 committees), open search

Convenor/coordinator of workshops
Symposium in honor of Robert R. L. Guillard: Marine Phytoplankton Research: Where We're At and Where We're Going. Conference Co-organizer (with E. Carpenter). Woods Hole. December 1989.

Convenor of workshop on collaborative marine pollution research programs between Marine Sciences Research Center, SUNY Stony Brook and Water Resources Division, US Geological Survey. Menlo Park, CA. March, 1990.

Conference on aquatic problems in eastern Europe. Co-organizer (with J. Schubel). Stony Brook. 1990.

International workshop on establishing research and training programs in the northwest Black Sea. Coordinator and chairman. Monaco, November, 1993.

Coordinator, CIESM Workshop on Bioaccumulation of Metals and Radionuclides in Marine Organisms. Ancona, Italy, October, 2002.

Coordinator, CIESM Workshop on Novel Contaminants and Pathogens Entering Coastal Waters. Neuchatel, Switzerland, May, 2004.

Chair activities outside the university

Workshop on "The Ocean Option for Future Waste Management." Woods Hole. January, 1991. Chair, Working Group on "Bioavailability of Chemicals in the Abyssal Ocean."

Review Meeting on "The National Ocean Pollution Plan, the Next Five Years" sponsored by NOAA. Stony Brook. January, 1991. Chair, Working Group on "Toxic Substances."

Review team of EPA's EMAP Program and its relationship to universities; Chair, Toxic Substances Working Group. Stony Brook. April, 1991.

Estuarine Research Federation Conference. Chair, session on Trophic Cycling of Materials in Estuaries. Presented a paper on: Marine colloids and the bioaccumulation and trophic transfer of metals in plankton. San Francisco. November, 1991.

Long Island Sound Monitoring workshop. Chair of toxic contaminants group. Stony Brook, December, 1993.

ASLO 97 Aquatic Sciences Meeting. Co-chair of Special Session on Metal Cycling in Marine and Freshwater Ecosystems. Co-author of the following presentations: “Metal and carbon assimilation in zebra mussels” (with H. Roditi); “Biological trace metal dynamics during a coastal diatom bloom” (with D. Hutchins); “Assimilation of sediment-bound trace metals in mussels: oxic vs. anoxic sediments” (with S. Griscom); “Bioavailability of Cr(III) and Cr(VI) to marine mussels from solute and particulate pathways” (with W. Wang); “Cycling and bioavailability of elements released by viral lysis of a marine phytoplankter” (with C. Gobler et al.). Santa Fe, NM, February, 1997.

Electric Power Research Institute Workshop on metal-biota interactions. Co-chair of group on trophic transfer of metals in aquatic food chains. Berkeley, CA, November 1997.

Society of Environmental Toxicology and Chemistry, 18th Annual Meeting. Co-chair of group on bioavailability of metals. Author/co-author of the following presentations: “Modeling metal bioaccumulation in marine copepods;” “Sublethal toxic response of zooplankton to silver: the importance of exposure route” (with S. Hook); “Combining toxicant kinetics, population dynamics

and trophic interactions" (with S. Ferson et al.); "Assimilation efficiency of Cd, Co, and Ag from ingested sediments" (with S. Griscom and S. Luoma); and "Allometry of trace element bioaccumulation in the mussel *Mytilus edulis*" (with W. Wang). San Francisco, CA, November, 1997.

International Symposium on Marine Pollution. Co-chaired session on "Bioimpacts." Presented paper on: "Implications of trophic transfer studies for developing water and sediment quality criteria." Monaco, October, 1998.

ASLO 2001 Aquatic Sciences Meeting. Co-chair of session on Trace Metal Limitation to Biogeochemistry. Author or co-author of the following presentations: "Biokinetic and bioenergetic constraints on the trace element content of juvenile striped bass," "Interspecific variability in bioaccumulation of Se by phytoplankton and its ecological implications" (with S. Baines), and "A novel technique for the quantification and localization of trace elements in plankton: synchrotron x-ray fluorescence microprobe." (with B. Twining et al.). Albuquerque, NM, February, 2001.

Society of Environmental Toxicology and Chemistry, 23rd Annual Meeting. Chair of session on Fate and Effects of Metals: Aquatic Dietary Perspectives. Author or co-author of the following presentations: "Kinetic modeling of metal bioaccumulation in clams: quantifying dietary and dissolved sources"(Fisher, Griscom, Luoma), and "Metal uptake by a benthic clam: relative importance of overlying water, oxic pore water and burrow water" (with Griscom). Salt Lake City, UT, November, 2002.

Other Meetings Attended (since 1982) * denotes invited participant/speaker

*Workshop on the behavior and control of radionuclides in the marine environment (Commission of the European Communities), Brussels. March 1982. Presented a paper on: Future Perspectives in Marine Radioecology.

*Workshop on regional activities in radioecological research (International Union of Radioecologists), Brussels. March 1982. Presented a paper on: Current research activities in the Mediterranean region.

Joint Oceanographic Assembly, Halifax. August 1982. Paper presented on: Biokinetics of transuranic elements in marine plankton.

Study Group meeting on the transfer of Am and Cm in the environment, Monaco. October 1982. Paper presented (with S. Fowler and S. Aston) on: Laboratory studies on the behavior of Am and Cm in the marine environment.

28th Congress of International Commission for the Scientific Exploration of the Mediterranean Sea, Cannes. December 1982. Presented papers on: Biokinetics of americium in marine plankton; and Radioecological research activities in the Mediterranean region.

*Laboratory workshop on behavior of Am in marine and freshwater systems, Mol, Belgium. January 1983. Organized and hosted by Radiobiology Department, Belgian Nuclear Center.

Fourth International Ocean Disposal Symposium, Plymouth, England. April 1983. Presented a paper entitled: The role of biogenic debris in the vertical transport of transuranic wastes in the sea.

*GESAMP Working Group on the Interchange of Pollutants between the Atmosphere and the Oceans. Athens, Greece. November 1983.

*Consultants meeting on key parameters for calculations required for definition of high-level wastes. IAEA, Vienna, Austria. February 1984.

Workshop on the role of microorganisms on the behavior of radionuclides in aquatic and terrestrial systems and their transfer to man. (International Union of Radioecologists), Brussels. April 1984. Presented a paper on: The concentration of radionuclides by marine phytoplankton.

*VIII International Symposium on Chemistry of the Mediterranean. Primosten, Yugoslavia. May 1984. Presented a paper on: Concentration of metals by marine phytoplankton: implications for toxicity and oceanic residence times.

*Gordon Research Conference on Environmental Sciences: Water. New Hampton, New Hampshire. June 1984. Presented a paper on: Metal accumulation by phytoplankton: physiological and geochemical implications.

29th Congress of International Commission for the Scientific Exploration of the Mediterranean Sea. Lucerne, Switzerland. October 1984. Presented papers on: Variations in algal sensitivity to metals; and Accumulation and retention of ^{241}Am and ^{237}Pu in the mussel *Mytilus edulis*.

*Expert Consultation on the Atmospheric Transport of Pollutants into the Mediterranean Region (WMO-coordinated GESAMP activity). Athens. January 1985.

Symposium on Speciation of Fission and Activation Products in the Environment. CEC and National Radiological Protection Board, U.K. Presented a paper on: Accumulation of ^{113}Sn by a marine diatom. Oxford. April 1985.

Fifth International Conference on Heavy Metals in the Environment. Presented a paper on: Algal growth under multiple toxicant limiting conditions. Athens. September 1985.

NATO Conference on Marine Picoplankton. San Mineato, Italy. October 1985.

*Consultation and laboratory experimentation in the Health Physics Department, Risø National Laboratory. Roskilde, Denmark. October 1985.

*Gordon Research Conference on Environmental Sciences: Water. New Hampton, New Hampshire. June 1986.

*DEPOFEX Workshop on Benthic Biogeochemical Processes. Walpole, Maine. June-July 1986.

Consultation on groundwater contamination, EAWAG (Swiss Federal Institute for Water Resources and Water Pollution Control). Dübendorf, Switzerland. May 1987.

International Symposium on Radioactivity and Oceanography. Société Francaise d'Énergie Nucléaire. Presented a paper on: Vertical flux of radionuclides in marine systems mediated by biogenic debris. Cherbourg, France. June 1987.

*Gordon Research Conference on Chemical Oceanography. Presented a paper on: Biota-metal interactions. Meriden, New Hampshire. August 1987.

*CHEMRAWN IV (Chemical Research Applied to World Needs). Modern Chemistry and Chemical Technology Applied to the Ocean and its Resources. Participant in panel on the nature of reactions on particle surfaces in seawater. Keystone, Colorado. October 1987.

Conference on Novel Phytoplankton Blooms, SUNY at Stony Brook, New York. Presented a paper on: Preliminary studies on the lipid composition of the "brown tide" alga. Stony Brook, New York. October 1988.

*Consultation with Water Resources Division, US Geological Survey, Menlo Park, California. Presented a seminar on: Radionuclide accumulation by marine biota. Menlo Park, California.

January 1989.

*Consultation with Subseabed Radioactive Waste Disposal Group, Sandia National Laboratory. Albuquerque, New Mexico. January 1989.

Consultation with International Laboratory of Marine Radioactivity. Presented a seminar on: Radionuclide flux and new production in the oceans. Monaco. February 1989.

*New York Bight monitoring workshop, sponsored by US Army Corps of Engineers. Presented a seminar on: Uptake of contaminants by marine organisms. Chair, Chemistry Panel. New York, New York. June 1989.

Consultation with International Laboratory of Marine Radioactivity on future directions of research in marine radioecology. Collaboration on experiments concerning radionuclide interactions with marine plankton. Monaco. August, 1989.

International Conference on Metals in Soils, Waters, Plants, and Animals. Presented (with S. Luoma & J. Reinfelder) papers on: Selenium bioconcentration by two benthic bivalves; and Selenium assimilation in two marine herbivores. Orlando, Florida. May, 1990.

32nd Congress of International Commission for the Scientific Exploration of the Mediterranean Sea. Perpignan, France. October, 1990. Presented paper on: Selenium assimilation in a marine copepod.

Consultation with I.A.E.A. International Laboratory of Marine Radioactivity, Monaco. October, 1990. Presented a seminar on: Colloidal association of metals in seawater and biogeochemical implications.

*Aquatic Toxicity Conference, Workshop on Geochemical Aspects of Metal Bioavailability. Vancouver. November, 1990. Presented a paper on: Trophic transfer of metals in aquatic systems.

*National Research Council working group meeting on wastewater treatment and impacts on coastal waters. Washington, D.C., February, 1991.

*American Society of Limnology and Oceanography Conference, Sante Fe. February 1992. Presented papers on: "The retention of metals in dying phytoplankton;" "Carbon remineralization and metal release rates from copepod fecal pellets and carcasses" (with B.-G. Lee).

*University of Rhode Island, Chemical Oceanography. Presented a talk on "Marine Colloids and the Bioavailability of Metals." March, 1992.

*American Geophysical Union Conference, Montreal. May 1992. Presented a talk on "The release of metals from decomposing planktonic debris."

*First International Environmental Workshop on Integrated Water and Wastewater Management.

Bari, Italy. October, 1992.

33rd Congress of International Commission for the Scientific Exploration of the Mediterranean Sea. Trieste, Italy. October, 1992. Presented paper on: The release of carbon and metals from decomposing phytoplankton.

*IUPAC workshop on trace metal speciation and bioavailability in aquatic systems. Presented paper on trophic transfer of metals in the sea. Plymouth, England, October, 1992.

*National Research Council Marine Board Planning Meeting on understanding, detecting, controlling and preventing eutrophication of coastal waters. Stony Brook, April, 1993.

*Interagency Arctic Research Policy Committee Workshop on Arctic Contamination. Presented paper on bioaccumulation of radionuclides, metals, and organic contaminants in marine food chains. Anchorage, May, 1993.

*University of Bologna. Presented three seminars on metal-plankton interactions in the oceans. Bologna, Italy, July, 1993.

*First International Conference on Transport, Fate and Effects of Silver in the Environment. Presented lecture on "Accumulation of Metals in Aquatic Organisms---Geochemical Implications." Madison, Wisconsin, August, 1993.

*Coastal Summit. Identification of current and future problems in the coastal ocean. Stony Brook, December, 1993.

*Lavaca Bay Conference on mercury contamination in a Texas estuary. Houston, February, 1994.

AGU/ASLO Conference. San Diego, February, 1994.

*Value Engineering Workshop to evaluate NYC DEP plan for Management of Jamaica Bay. New York, New York, June, 1994.

*Value Engineering Workshop to evaluate NYC DEP plan for Management of Paerdegat Basin, New York, New York, July 1994.

*Second International Conference on Transport, Fate and Effects of Silver in the Environment. Presented lecture on "Bioaccumulation of silver in marine bivalve molluscs." Madison, Wisconsin, August, 1994.

*McGill University. Presented seminar on "Recent studies on metal-plankton interactions." Montreal, October, 1994.

*Office of Naval Research. Workshop on Monitoring of Nuclear Contamination in Arctic Seas.

Presented a seminar on "Biological monitoring for radioactive wastes in the Russian Arctic." Washington, D.C., January, 1995.

34th Congress of International Commission for the Scientific Exploration of the Mediterranean Sea. Malta. March, 1995. Presented paper on: Bioaccumulation and retention of radionuclides in marine bivalves.

*Office of Naval Research. Arctic Nuclear Waste Assessment Program Workshop. Presented seminar and poster on bioindicators of radioactive wastes in the Arctic. Woods Hole, May, 1995.

*Third International Conference on Transport, Fate and Effects of Silver in the Environment. Presented lecture on "A comparison of sediment, water and food as sources of silver for marine bivalve molluscs." Washington, D. C., August, 1995.

*Office of Naval Research. Arctic Nuclear Waste Assessment Program Workshop on Risk Assessment. Presented a lecture on "Bioconcentration factors and sediment Kds of long-lived radionuclides in the Ob River Estuary and Kara Sea." Sequim, Washington, October, 1995.

*Brown Tide Summit. Conference on the occurrence, causes and impacts of the "brown tide" in New York coastal waters. Workshop participant in chemical causes of the brown tide. Islip, New York, October, 1995.

*International Atomic Energy Agency. Consultants' Group Meeting on concentration factors and sediment Kd values of long-lived radionuclides in the Arctic. Monaco, November, 1995.

Ocean Sciences Meeting, American Geophysical Union. Presented 4 papers: "Kinetic determination of trace element bioaccumulation in the mussel *Mytilus edulis*" (with W. Wang); "Modeling metal bioaccumulation in the mussel *Mytilus edulis*"; Assimilation of sediment-bound Cd, Co, Ag in the mussel *Mytilus edulis*" (with S. Griscom); "The biogeochemical fate of phytoplankton Fe: mechanisms and controls" (with D. Hutchins et al.). San Diego, February, 1996.

*Old Dominion University. Presented a seminar on "Looking for patterns in metal-biota interactions in the sea." Norfolk, VA, April, 1995.

*Office of Naval Research. Arctic Nuclear Waste Assessment Program Conference. Presented two papers: "Biomonitoring of radionuclides in the Kara Sea" and "Transport and fate of anthropogenic radionuclides in the Ob River system." Snowbird, Utah, May, 1996.

*Fourth International Conference on Transport, Fate and Effects of Silver in the Environment. Presented seminars on "Kinetic modeling of metal accumulation in mussels" and "Assimilation of metals by the zebra mussel, *Dreissena polymorpha*." Madison, Wisconsin, August, 1996.

*International Symposium on Radionuclides in the Oceans. Presented a seminar on "Application of radiotracers for studying trace element accumulation in mussels." Cherbourg, France, October,

1996.

*Value Engineering Workshop Implementation Meeting for Jamaica Bay Comprehensive Watershed Management Plan. New York, NY, October, 1996.

Society of Environmental Toxicology and Chemistry, 17th Annual Meeting. Presented three papers on "Kinetic determinations of trace element accumulation in the mussel *Mytilus edulis*" (with Wang and Luoma); "PCB cycling in marine plankton" (with Ashizawa and Brownawell); "Bioavailability of trace contaminants ^{241}Am, ^{57}Co, ^{137}Cs to a benthic bivalve from pore waters and sediments" (with Gagnon and Stupakoff). Washington, D.C., November, 1996.

*Participated as member of Advisory panel of COASTES program at Academy of Natural Sciences Benedict Estuarine Research Center, St. Leonard, MD, February, 1997.

*Fifth International Conference on Transport, Fate and Effects of Silver in the Environment. Presented lectures on "Silver accumulation and toxicity in marine and freshwater zooplankton;" "Using silver to trace sewage input into the Adriatic Sea" (with S. Fonda Umani). Hamilton, Ontario, Canada, September, 1997.

*Participated as member of Advisory panel of COASTES program at Academy of Natural Sciences Benedict Estuarine Research Center, St. Leonard, MD, March, 1998.

35th Congress of International Commission for the Scientific Exploration of the Mediterranean Sea. Presented paper on: "Modeling the bioaccumulation of trace metals in marine herbivores." Dubrovnik, Croatia. June, 1998.

Fifty Years of Ocean Discovery. National Academy of Sciences and National Science Foundation. Presented a poster on: "MSRC: 30 years of innovative coastal research." Washington, D.C., October, 1998.

Society of Environmental Toxicology and Chemistry, 19th Annual Meeting. Author/co-author of the following presentations: "Modeling and measuring metal accumulation in marine copepods," "Bioavailability of metals from sediments to a deposit-feeding polychaete" (with W.-X. Wang); "Influence of exposure route on sublethal toxicity of silver and selenium to zooplankton" (with S. Hook). Charlotte, NC, November, 1998.

*City University of Hong Kong. Presented a seminar on "Modeling and measuring metal bioaccumulation in marine invertebrates." Hong Kong, January, 1999.

*Hong Kong University of Science and Technology. Presented a seminar on "Looking for patterns in the biogeochemistry of metals in the oceans." Hong Kong, January, 1999.

ASLO 99 Aquatic Sciences Meeting. Author/co-author of the following presentations: "Modeling and measuring metal accumulation in marine copepods;" "Gut redox conditions and the assimilation

of sediment-bound metals in two marine bivalves" (with S. Griscom); "Interactions of zebra mussels (*Dreissena polymorpha*) with high molecular weight colloidal trace elements and carbon" (with H. Roditi); "Uptake of dissolved selenium by phytoplankton: is organic selenium readily incorporated and do uptake rates differ among taxa?" (with S. Baines). Santa Fe, NM, February, 1999.

*University of Delaware. Presented a seminar on "Looking for patterns in metal-biota interactions in the oceans." Lewes, DE, April, 1999.

*Hudson River Foundation. Presented a seminar on "Looking for patterns in metal-biota interactions in the oceans." New York, NY, May, 1999.

*Hudson River Monitoring Workshop. Millbrook, NY, July, 1999.

*Dartmouth College. Presented a seminar on "Looking for patterns in metal-biota interactions in the oceans." Hanover, NH, October, 1999.

Society of Environmental Toxicology and Chemistry, 20th Annual Meeting. Co-author of the following presentations: "Reassessing metal bioavailability in contaminated sediments: influence of AVS (porewater) vs dietary uptake" (with B.-G. Lee et al.); "Reproductive toxicity of silver and mercury to zooplankton: the importance of exposure route" (with S. Hook). Philadelphia, PA, November, 1999.

*Electric Power Research Institute. Presented a seminar on "Uptake of metals and dissolved organic carbon by zebra mussels." Palo Alto, CA, April, 2000.

*International Atomic Energy Agency. Consultants Group meeting on sediment Kds and bioconcentration factors for radionuclides in the marine environment. Monaco, April, 2000.

ASLO 2000 Aquatic Sciences Meeting. Author of the following presentations: "Uptake of dissolved organic carbon and trace metals by zebra mussels," and "Field-testing a metal bioaccumulation model for zebra mussels." Copenhagen, June, 2000.

*Alfred-Wegener Institute for Polar and Marine Research. Presented a seminar on "Looking for patterns in metal-biota interactions in the oceans." Bremerhaven, Germany, June, 2000.

CALFED Science Conference. Presented seminars on "Assimilation of selenium from food by striped bass larvae" and "Bioaccumulation of selenium by phytoplankton" (with S. Baines). Sacramento, CA, October, 2000.

Institute of Ecosystem Studies. Presented a seminar on "Zebra mussel-trace metal interactions." Millbrook, NY, October, 2000.

*International Atomic Energy Agency. Consultants Group meeting on sediment Kds and bioconcentration factors for radionuclides in the marine environment. Vienna, November, 2000.

Society of Environmental Toxicology and Chemistry, 21st Annual Meeting. Author or co-author of the following presentations: "Modeling metal uptake in zebra mussels: the importance of diet," "Sublethal toxicity of metals to marine copepods following dietary exposure: a consistent pattern emerges" (with S. Hook), and "Trophic transfer of metals to estuarine zooplankton via grazing on protozoa" (with B. Twining). Nashville, TN, November, 2000.

*Site Visit Review Team for NSERC research proposal. Dalhousie University, Halifax, January, 2001.

*EPRI/EPA Workshop to review the Biotic Ligand Model. Presented a talk on "Relating metal toxicity to bioaccumulation and uptake pathways in aquatic animals." Washington, D.C., January, 2001.

*Working Group for the establishment of a research agenda for a new Hudson River institute. West Point, NY, February, 2001.

*Low level radioactive municipal solid waste conference. Presented a seminar on "Basic radiation concepts." Stony Brook, NY, April, 2001.

* Rutgers University. Presented a seminar on "Some recent studies on the trophic transfer of metals in marine ecosystems." New Brunswick, NJ, October, 2001.

Society of Environmental Toxicology and Chemistry, 22nd Annual Meeting. Author or co-author of the following presentations: "Influence of colloids on metal-biota interactions in marine systems," "Bioaccumulation and trophic transfer of thallium in Great Lakes plankton communities" (with B. Twining and M. Twiss), "Reproductive toxicity of metals to marine copepods following dietary exposure" (with S. Hook), and "Quantification of trace metals in natural plankton using a synchrotron x-ray fluorescence microprobe" (with B. Twining et al.). Baltimore, MD, November, 2001.

Marine Environment Laboratory, International Atomic Energy Agency, Monaco. Presented a seminar on "A review of recent modeling efforts examining metal bioaccumulation in marine animals." Monaco, November, 2001.

*CIESM Science Council Chairs Retreat. Istanbul, January, 2002.

*JGOFS Workshop on the Mesopelagic Zone. Presented a talk on "Mechanisms regulating elemental cycling and decomposition of planktonic debris." San Antonio, March, 2002.

*CIESM Workshop on establishing a bioindicator program for contaminants in the Mediterranean. Presented a talk on "Considerations for a mussel-based monitoring program for radioactive contaminants in the Mediterranean Sea." Marseille, April, 2002.

ASLO 2002 Aquatic Sciences Meeting. Author or co-author of the following presentations:

"Utilization of natural dissolved organic carbon by the zebra mussel, *Dreissena polymorpha*" (Fisher, Baines, Cole), "Bioaccumulation, redox cycling, and trophic transfer of thallium by great lakes plankton communities" (with Twining and Twiss), "Kinetic modeling of metal accumulation in the clam, *Macoma balthica*: quantifying food and dissolved sources" (with Griscom and Luoma), "Trace element concentrations and stoichiometries in planktonic protists measured with an X-ray fluorescence microprobe" (with Baines et al.), "Prediction of trace metal bioavailability in fresh waters based on complexation characteristics to dissolved organic matter" (with Mylon et al.), and "Uptake and trophic transfer of polonium in marine plankton" (with Stewart). Victoria, British Columbia, Canada, June, 2002.

*SETAC Technical Workshop On the Role of Dietary Exposures in the Evaluation of Risk of Metals to Aquatic Animals. Fairmont Hot Springs, British Columbia, Canada, July, 2002.

International Conference on Radioactivity in the Environment. Presented a seminar on "Advantages and problems in the application of radiotracers for determining the bioaccumulation of contaminants in aquatic organisms. Monaco, September, 2002.

*Dartmouth College. Presented two lectures on marine pollution and invited seminar on "New approaches to understanding metal-plankton interactions in aquatic systems." Hanover, NH, November, 2002.

*International Atomic Energy Agency. Consultants Group meeting on sediment Kds and bioconcentration factors for radionuclides in the marine environment. Vienna, December, 2002.

*CIESM Chairs retreat. Majorca, Spain, December, 2002.

*EPA Metals Assessment Workshop. Washington, D.C., December, 2002.

ASLO 2003 Aquatic Sciences Meeting. Co-author of the following presentations: "Opening the 'black box': elemental stoichiometries of autotrophic and heterotrophic protists in the Southern Ocean" (with Twining et al.), "Direct uptake of dissolved organic selenium by riverine phytoplankton inferred from selenite:C uptake ratios and Se:C in suspended particles" (with Baines et al.), "Radioactive polonium, lead and thorium as tracers of organic carbon flux in the surface ocean" (with Stewart et al.). Salt Lake City, February, 2003.

*Dartmouth College. Presented two lectures on "Marine pollution: transport, bioaccumulation, and effects of contaminants." Hanover, NH, October, 2003.

*Brookhaven National Laboratory. Presented a talk on "Influence of colloids on metal-biota interactions in marine systems." Upton, NY, November 2003.

*CIESM Science Council Chairs retreat. Chania, Crete, Greece, November, 2003.

*IAEA Coordinated Research Program on Nuclear Applications to Determine Bioaccumulation

Parameters and Processes used for Establishing Coastal Zone Monitoring and Management Criteria. Presented a talk on "Integrating bioaccumulation data and modeling for understanding radionuclide concentrations in aquatic animal tissues." Monaco, December, 2003.

*CIESM Science Council Chairs retreat. Monaco, February, 2004.

*CIESM Workshop on Novel Contaminants and Pathogens Entering Coastal Waters. Presented a paper on "Medical radioisotopes entering the marine environment." Neuchatel, Switzerland, May, 2004

*EAWAG. Presented a seminar on "New approaches to thinking about metal-biota interactions in marine systems." Zurich, Switzerland, May, 2004.

*CIESM 37th Congress. Organized and chaired sessions on Biogeochemistry. Presented a paper on "Metal cycling through plankton communities: a single-cell approach using synchrotron-based x-ray fluorescence." Barcelona, June, 2004.

*DOD, DOE, EPA Strategic Environmental Research and Development Program Workshop on Contaminated Sediments. Co-presented a paper on "Fate and transport of sediment-associated contaminants" (with R.M. Dickhut). Charlottesville, VA, August, 2004.

*Conference on Future Applications of ^{234}Th in Aquatic Ecosystems. Woods Hole, MA, August, 2004.

*CIESM Science Council Chairs Retreat. La Rochelle, France, September, 2004.

*Conference on Classic and Emerging Environmental Contaminants: from Lakes to Oceans. Chaired session on novel organic contaminants. Dubendorf, Switzerland, January, 2005.

*Station Zoologique. Presented seminar on "New approaches to studying metal-biota interactions in the sea." Villefranche, France, March, 2005.

*University of the Aegean. Presented three seminars on "Trace metal geochemistry in the oceans," "Bioaccumulation of metals in marine organisms." "Toxicity of metals to marine organisms." Mytilene, Greece, April, 2005.

*IAEA Coordinated Research Program on Nuclear Applications to Determine Bioaccumulation Parameters and Processes used for Establishing Coastal Zone Monitoring and Management Criteria. Presented a talk on "Radiotracer studies of mercury and methylmercury bioaccumulation in aquatic food chains." Monaco, May, 2005.

The Oceanography Society, International Ocean Research Conference. Presented a seminar on "Exploring stoichiometric responses of Southern Ocean plankton to iron fertilization using synchrotron-based x-ray fluorescence microscopy." Paris, France, June, 2005

ASLO 2005 Aquatic Sciences Meeting. Presented a seminar on “How plankton affect carbon to thorium ratios in sinking particles.” Santiago de Compostela, Spain, June, 2005.

*Hudson River Foundation Long Range Planning Workshop on Chemical Contaminants. New York, July, 2005.

*CIESM Workshop on Production and Fate of Dissolved Organic Matter in the Mediterranean Sea. Presented a talk on “Dying plankton as a source of dissolved organic matter.” Cambados, Spain, September, 2005.

*External Advisory Committee review of Dartmouth College’s Center for Environmental Health Sciences. Hanover, NH, November, 2005.

Society of Environmental Toxicology and Chemistry, 26th Annual Meeting. Presented “Accumulation of inorganic and organic mercury in phytoplankton and the subsequent trophic transfer to crustaceans” (with P. Pickhardt). Baltimore, MD, November, 2005.

8th International Conference on Mercury as a Global Pollutant. Presented “Uptake of mercury to freshwater phytoplankton and the successive trophic transfer to crustacean grazers” (with P. Pickhardt). Madison, WI, August, 2006.

PUBLICATIONS

Fisher, N.S. Effects of chlorinated hydrocarbon pollutants on growth of marine phytoplankton in culture. Ph.D. Thesis, State University of New York at Stony Brook, 1974; University Microfilms (Ann Arbor, Michigan), Publ. No. 74-27824, 195 pp; Dissertation Abstracts 35:2917-B (1974).

Mosser, J.L., N.S. Fisher, T.-C. Teng, and C.F. Wurster. 1972. Polychlorinated biphenyls: toxicity to certain phytoplankters. **Science** 175: 191-192.

Mosser, J.L., N.S. Fisher, and C.F. Wurster. 1972. Polychlorinated biphenyls and DDT alter species composition in mixed cultures of algae. **Science** 176: 533-535.

Fisher, N.S., L.B. Graham, E.J. Carpenter, and C.F. Wurster. 1973. Geographic differences in phytoplankton sensitivity to PCBs. **Nature** 241: 548-549.

Fisher, N.S., and C.F. Wurster. 1973. Individual and combined effects of temperature and polychlorinated biphenyls on the growth of three species of phytoplankton. **Environmental Pollution** 5: 205-212.

Fisher, N.S., E.J. Carpenter, C.C. Remsen, and C.F. Wurster. 1974. Effects of PCB on interspecific competition in natural and gnotobiotic phytoplankton communities in continuous and batch cultures. **Microbial Ecology** 1: 39-50.

Fisher, N.S., and C.F. Wurster. 1974. Impact of pollutants on plankton communities. **Environmental Conservation** 1: 189-190.

Fisher, N.S. 1975. Chlorinated hydrocarbon pollutants and photosynthesis of marine phytoplankton: a reassessment. **Science** 189: 463-464.

Powers, C.D., R.G. Rowland, R.A. Michaels, N.S. Fisher, and C.F. Wurster. 1975. The toxicity of DDE to a marine dinoflagellate. **Environmental Pollution** 9: 253-262.

Fisher, N.S., R.R.L. Guillard, and C.F. Wurster. 1976. Effects of a chlorinated hydrocarbon pollutant on the growth kinetics of a marine diatom. In: Modeling Biochemical Processes in Aquatic Ecosystems, R.P. Canale (Ed.), Ann Arbor Science Publishers, Ann Arbor, pp. 305-317.

Fisher, N.S. 1976. North Sea phytoplankton. **Nature** 259: 160.

Bankston, D.C., and N.S. Fisher. 1977. Atomic emission spectrometer/spectrograph for the determination of barium in microamounts of diatom ash. **Analytical Chemistry** 49: 1017-1023.

Fisher, N.S. 1977. On the differential sensitivity of estuarine and open-ocean diatoms to exotic

chemical stress. **American Naturalist** 111: 871-895.

Schwarzenbach, R.P., and N.S. Fisher. 1978. Rapid determination of the molecular weight distribution of total cellular fatty acids using chemical ionization mass spectrometry. **Journal of Lipid Research** 19: 12-17.

Fisher, N.S., and R.P. Schwarzenbach. 1978. Fatty acid dynamics in *Thalassiosira pseudonana* (Bacillariophyceae): implications for physiological ecology. **Journal of Phycology** 14: 143-150.

Pechenik, J.A., and N.S. Fisher. 1979. Feeding, assimilation, and growth of mud snail larvae, *Nassarius obsoletus* (Say), on three different algal diets. **Journal of Experimental Marine Biology and Ecology** 38: 57-80.

Fisher, N.S. 1979. On habitat predictability and algal pre-adaptation to novel chemicals - comments. **American Naturalist** 113: 946-947.

Bankston, D.C., N.S. Fisher, R.R.L. Guillard, and V.T. Bowen. 1979. Application of dc plasma optical emission spectrometry to studies of element incorporation by marine phytoplankton. **EML Environmental Quarterly** 1509-1531.

Fisher, N.S., B.L. Olson, and V.T. Bowen. 1980. Plutonium uptake by marine phytoplankton in culture. **Limnology and Oceanography** 25: 823-839.

Fisher, N.S., and D. Frood. 1980. Heavy metals and marine diatoms: influence of dissolved organic compounds on toxicity and selection for metal tolerance among four species. **Marine Biology** 59: 85-93.

Fisher, N.S., G.J. Jones, and D.M. Nelson. 1981. Effects of copper and zinc on growth, morphology, and metabolism of *Asterionella japonica* (Cleve). **Journal of Experimental Marine Biology and Ecology** 51: 37-56.

Fisher, N.S., and G.J. Jones. 1981. Heavy metals and marine phytoplankton: correlation of toxicity and sulfhydryl-binding. **Journal of Phycology** 17: 108-111.

Fisher, N.S. 1981. On the selection for heavy metal tolerance in diatoms from the Derwent Estuary, Tasmania. **Australian Journal of Marine and Freshwater Research** 32: 555-561.

Fisher, N.S. 1981. Sensitivity of phytoplankton to pollutants. In: Marine Botany: An Australasian Perspective, M. Clayton and R. King (Eds.), Longman Cheshire, Melbourne, pp. 285-290.

Butler, E.C.V., J.D. Smith, and N.S. Fisher. 1981. Influence of phytoplankton on iodine speciation in seawater. **Limnology and Oceanography** 26: 382-386.

Romeo, A.J., and N.S. Fisher. 1982. Intraspecific comparisons of nitrate uptake in three marine diatoms. **Journal of Phycology** 18: 220-225.

Fisher, N.S., and J.G. Fabris. 1982. Complexation of Cu, Zn and Cd by metabolites excreted from marine diatoms. **Marine Chemistry** 11: 245-255.

McConville, M.J., N.S. Fisher, and A.E. Clarke. 1982. Relationship between evolutionary age and hydroxyproline-containing macromolecules in unicellular algae. **Phytochemistry** 21: 2243-2248.

Fisher, N.S. 1982. Bioaccumulation of technetium by marine phytoplankton. **Environmental Science and Technology** 16: 579-581.

Fisher, N.S., and R.A. Cowdell. 1982. Growth of marine planktonic diatoms on inorganic and organic nitrogen. **Marine Biology** 72: 147-155.

Gillan, F.T., N.S. Fisher, and R.B. Johns. 1983. The effects of copper and zinc on the fatty acids and carotenoids in the marine diatom *Asterionella japonica*. **Botanica Marina** 26: 255-257.

Fisher, N.S., K.A. Burns, R.D. Cherry, and M. Heyraud. 1983. Accumulation and cellular distribution of ^{241}Am, ^{210}Po, and ^{210}Pb in two marine algae. **Marine Ecology Progress Series** 11: 233-237.

Fisher, N.S., P. Bjerregaard, and S.W. Fowler. 1983. Interactions of marine plankton with transuranic elements. I. Biokinetics of neptunium, plutonium, americium, and californium in phytoplankton. **Limnology and Oceanography** 28: 432-447.

Fisher, N.S., P. Bjerregaard, L. Huynh-Ngoc, and G.R. Harvey. 1983. Interactions of marine plankton with transuranic elements. II. Influence of dissolved organic compounds on americium and plutonium accumulation in a diatom. **Marine Chemistry** 13: 45-56.

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Fisher, N.S., and S.W. Fowler. 1983. Radioecological research activities (particularly marine-related) in the Mediterranean region and nearby countries. **Rapp. Comm. Int. Mer. Medit.** 28: 189-203.

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Fowler, S.W., and N.S. Fisher. 1983. Viability of marine phytoplankton in zooplankton fecal

pellets. **Deep-Sea Research** 30: 963-969.

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Help

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***** U N O F F I C I A L *****

University of California, Santa Cruz
1156 High Street
Santa Cruz, CA 95064
United States

Name : Luengen,Allison Christine
Student ID: 0140851
Print Date : 2006-08-30

- - - - - Degrees Awarded - - - - -

Degree : Master of Science
Confer Date : 2001-06-07
Plan : MS in Marine Sciences

- - - - - Beginning of Graduate Record - - - - -

1998 Fall Quarter

Program : Marine Sciences Graduate
Plan : Marine Sciences MS Graduate Course of Study
INTERCAMPUS GRADUATE EXCHANGE PROGRAM

OCEA	120	Aquatic Chemistry	5.00	5.00	S
OCEA	200	Ocean Atmos Climate	5.00	5.00	S
OCEA	292	Seminar		0.00	S
OCEA	299A	Thesis Research	5.00	5.00	S
PHYE	9B	Basic Sailing		0.00	P
XPHA	230	Adv Topics Phrm/Tox	3.00	3.00	B

Grading Basis: External Program
Notes : COURSE ID - PHRM-TX 230 - UC DAVIS

TERM GPA :	0.00	TERM TOTALS :	18.00	18.00	0.00
CUM GPA :	0.00	CUM TOTALS :	18.00	18.00	0.00

1999 Winter Quarter

Program : Marine Sciences Graduate
Plan : Marine Sciences MS Graduate Course of Study

EART	226	Aquatic Toxicology	5.00	5.00	S
MATH	7	Intro Biostatistics	5.00	5.00	S
OCEA	292	Seminar		0.00	S

OCEA	299A	Thesis Research	5.00	5.00	S
OCEA	301	Superv Teach Exp		0.00	S
PHYE	9C	Intermediat Sailing		0.00	P

TERM GPA : 0.00 TERM TOTALS : 15.00 15.00 0.00

CUM GPA : 0.00 CUM TOTALS : 33.00 33.00 0.00

1999 Spring Quarter

Program : Marine Sciences Graduate

Plan : Marine Sciences MS Graduate Course of Study

OCEA	220	Chemical Oceanograp	5.00	5.00	S
OCEA	290M	Compar Toxicology	5.00	5.00	S
OCEA	299A	Thesis Research	5.00	5.00	S
PHYE	9C	Intr Sailing Dinghy		0.00	P

TERM GPA : 0.00 TERM TOTALS : 15.00 15.00 0.00

CUM GPA : 0.00 CUM TOTALS : 48.00 48.00 0.00

1999 Fall Quarter

Program : Marine Sciences Graduate

Plan : Marine Sciences MS Graduate Course of Study

CHEM	122	Instrumental Analys	5.00	5.00	S
EART	290M	Environ Toxicology	2.00	2.00	A
OCEA	299B	Thesis Research	10.00	10.00	S
PHYE	9C	Intermed Sailing		0.00	P

TERM GPA : 0.00 TERM TOTALS : 17.00 17.00 0.00

CUM GPA : 0.00 CUM TOTALS : 65.00 65.00 0.00

2000 Winter Quarter

Program : Marine Sciences Graduate

Plan : Marine Sciences MS Graduate Course of Study

EART	226	Aquatic Toxicology	5.00	5.00	A
OCEA	280	Marine Geology	5.00	5.00	S
OCEA	292	Seminar		0.00	S
OCEA	299A	Thesis Research	5.00	5.00	A

TERM GPA : 0.00 TERM TOTALS : 15.00 15.00 0.00

CUM GPA : 0.00 CUM TOTALS : 80.00 80.00 0.00

2000 Spring Quarter

Program : Marine Sciences Graduate
Plan : Marine Sciences MS Graduate Course of Study

EART	290S	Aquatic Pollutants	5.00	5.00	A
OCEA	292	Seminar		0.00	S
OCEA	299B	Thesis Research	10.00	10.00	A
PHYE	9C	Inter Sail-Keelboat		0.00	P

TERM GPA : 0.00 TERM TOTALS : 15.00 15.00 0.00

CUM GPA : 0.00 CUM TOTALS : 95.00 95.00 0.00

2000 Fall Quarter

Program : Marine Sciences Graduate
Plan : Marine Sciences MS Graduate Course of Study
Program : Environmental Toxicology Grad
Plan : Environmental Toxicology PhD Graduate Course of Study

ETOX	201	Environ Toxicology	5.00	5.00	A
ETOX	205	Intro Grad Seminar		0.00	S
ETOX	281F	Topics Aquatic Tox	5.00	5.00	A
ETOX	297	Independent Study	5.00	5.00	A

TERM GPA : 0.00 TERM TOTALS : 15.00 15.00 0.00

CUM GPA : 0.00 CUM TOTALS : 110.00 110.00 0.00

2001 Winter Quarter

Program : Marine Sciences Graduate
Plan : Marine Sciences MS Graduate Course of Study
Program : Environmental Toxicology Grad
Plan : Environmental Toxicology PhD Graduate Course of Study

ETOX	202	Environ Toxicology	5.00	5.00	A
ETOX	205	Intro Grad Seminar		0.00	S
ETOX	281F	Topics Aquatic Tox	5.00	5.00	A
ETOX	297	Independent Study	5.00	5.00	A

TERM GPA : 0.00 TERM TOTALS : 15.00 15.00 0.00

CUM GPA : 0.00 CUM TOTALS : 125.00 125.00 0.00

2001 Spring Quarter

Program : Marine Sciences Graduate
Plan : Marine Sciences MS Graduate Course of Study
Program : Environmental Toxicology Grad
Plan : Environmental Toxicology PhD Graduate Course of Study

ETOX	205	Intro Grad Seminar		0.00	S
ETOX	281F	Topics Aquatic Tox	5.00	5.00	A
ETOX	297	Independent Study	5.00	5.00	A
ETOX	297	Independent Study	5.00	5.00	A
OCEA	292	Seminar		0.00	S
PHYE	9D	Int/Adv Sail-Keel		0.00	P

TERM GPA : 0.00 TERM TOTALS : 15.00 15.00 0.00

CUM GPA : 0.00 CUM TOTALS : 140.00 140.00 0.00

2001 Summer Quarter

Program : Environmental Toxicology Grad

Plan : Environmental Toxicology PhD Graduate Course of Study

ETOX	297A	Independent Study	5.00	5.00	S

TERM GPA : 0.00 TERM TOTALS : 5.00 5.00 0.00

CUM GPA : 0.00 CUM TOTALS : 145.00 145.00 0.00

2001 Fall Quarter

Program : Environmental Toxicology Grad

Plan : Environmental Toxicology PhD Graduate Course of Study

BIOL	110	Cell Biology	5.00	5.00	S
ETOX	205	Intro Grad Seminar		0.00	S
ETOX	281F	Topics Aquatic Tox	5.00	5.00	A
ETOX	297	Independent Study	5.00	5.00	A

TERM GPA : 0.00 TERM TOTALS : 15.00 15.00 0.00

CUM GPA : 0.00 CUM TOTALS : 160.00 160.00 0.00

2002 Winter Quarter

Program : Environmental Toxicology Grad

Plan : Environmental Toxicology PhD Graduate Course of Study

ETOX	205	Intro Grad Seminar		0.00	S
ETOX	281F	Topics Aquatic Tox	5.00	5.00	A
ETOX	297	Independent Study	5.00	5.00	A
ETOX	297	Independent Study	5.00	5.00	A
PHYE	9C	Int Sailing Keelboat		0.00	P

TERM GPA : 0.00 TERM TOTALS : 15.00 15.00 0.00

CUM GPA : 0.00 CUM TOTALS : 175.00 175.00 0.00

2002 Spring Quarter

Program : Environmental Toxicology Grad
Plan : Environmental Toxicology PhD Graduate Course of Study

ETOX	203	Interdisc Training	5.00	5.00	S
ETOX	205	Intro Grad Seminar		0.00	S
ETOX	297	Independent Study	5.00	5.00	A
ETOX	297	Independent Study	5.00	5.00	A

TERM GPA : 0.00 TERM TOTALS : 15.00 15.00 0.00

CUM GPA : 0.00 CUM TOTALS : 190.00 190.00 0.00

2002 Fall Quarter

Program : Environmental Toxicology Grad
Plan : Environmental Toxicology PhD Graduate Course of Study

ETOX	281F	Topics Aquatic Tox	5.00	5.00	A
ETOX	292	Intro Grad Seminar		0.00	S
ETOX	297	Independent Study	5.00	5.00	A
ETOX	297	Independent Study	5.00	5.00	A

TERM GPA : 0.00 TERM TOTALS : 15.00 15.00 0.00

CUM GPA : 0.00 CUM TOTALS : 205.00 205.00 0.00

2003 Winter Quarter

Program : Environmental Toxicology Grad
Plan : Environmental Toxicology PhD Graduate Course of Study

ETOX	281F	Topics Aquatic Tox	5.00	5.00	A
ETOX	292	Intro Grad Seminar		0.00	S
ETOX	297	Independent Study	5.00	5.00	A
OCEA	224	Aqua Org Geochem	5.00	5.00	S

TERM GPA : 0.00 TERM TOTALS : 15.00 15.00 0.00

CUM GPA : 0.00 CUM TOTALS : 220.00 220.00 0.00

2003 Spring Quarter

Program : Environmental Toxicology Grad
Plan : Environmental Toxicology PhD Graduate Course of Study

ETOX	281F	Topics Aquatic Tox	5.00	5.00	A
ETOX	292	Intro Grad Seminar		0.00	S
ETOX	299B	Thesis Research	10.00	10.00	A

TERM GPA : 0.00 TERM TOTALS : 15.00 15.00 0.00

	CUM GPA :	0.00	CUM TOTALS :	235.00	235.00		0.00

2003 Fall Quarter

Program : Environmental Toxicology Grad
Plan : Environmental Toxicology PhD Graduate Course of Study

ETOX	281F	Topics Aquatic Tox	5.00	5.00	A
ETOX	292	Intro Grad Seminar		0.00	S
ETOX	297	Independent Study	5.00	5.00	A
ETOX	297	Independent Study	5.00	5.00	A
	TERM GPA : 0.00	TERM TOTALS :	15.00	15.00	0.00
	CUM GPA : 0.00	CUM TOTALS :	250.00	250.00	0.00

2004 Winter Quarter

Program : Environmental Toxicology Grad
Plan : Environmental Toxicology PhD Graduate Course of Study

BIOL	286	Exp Dsgn/Data Anlys	5.00	5.00	S
ETOX	281F	Topics Aquatic Tox	5.00	5.00	A
ETOX	292	Intro Grad Seminar		0.00	S
ETOX	297A	Independent Study	5.00	5.00	A
	TERM GPA : 0.00	TERM TOTALS :	15.00	15.00	0.00
	CUM GPA : 0.00	CUM TOTALS :	265.00	265.00	0.00

2004 Spring Quarter

Program : Environmental Toxicology Grad
Plan : Environmental Toxicology PhD Graduate Course of Study

ETOX	281F	Topics Aquatic Tox	5.00	5.00	A
ETOX	292	Intro Grad Seminar		0.00	S
ETOX	299B	Thesis Research	10.00	10.00	A
	TERM GPA : 0.00	TERM TOTALS :	15.00	15.00	0.00
	CUM GPA : 0.00	CUM TOTALS :	280.00	280.00	0.00

2004 Fall Quarter

Program : Environmental Toxicology Grad
Plan : Environmental Toxicology PhD Graduate Course of Study

ETOX	281F	Topics Aquatic Tox	5.00	5.00	A
ETOX	292	Intro Grad Seminar		0.00	S
ETOX	299B	Thesis Research	10.00	10.00	A
	TERM GPA : 0.00	TERM TOTALS :	15.00	15.00	0.00

	CUM GPA :	0.00	CUM TOTALS :	295.00	295.00	0.00

2005 Winter Quarter

Program : Environmental Toxicology Grad
Plan : Environmental Toxicology PhD Graduate Course of Study

ETOX	292	Intro Grad Seminar		0.00	S
ETOX	299C	Thesis Research	15.00	15.00	A
	TERM GPA : 0.00	TERM TOTALS :	15.00	15.00	0.00
	CUM GPA : 0.00	CUM TOTALS :	310.00	310.00	0.00

2005 Spring Quarter

Program : Environmental Toxicology Grad
Plan : Environmental Toxicology PhD Graduate Course of Study

ETOX	292	Intro Grad Seminar		0.00	S
ETOX	299C	Thesis Research	15.00	15.00	A
	TERM GPA : 0.00	TERM TOTALS :	15.00	15.00	0.00
	CUM GPA : 0.00	CUM TOTALS :	325.00	325.00	0.00

2005 Fall Quarter

Program : Environmental Toxicology Grad
Plan : Environmental Toxicology PhD Graduate Course of Study

ETOX	281F	Topics Aquatic Tox	5.00	5.00	A
ETOX	292	Intro Grad Seminar		0.00	S
ETOX	299B	Thesis Research	10.00	10.00	A
	TERM GPA : 0.00	TERM TOTALS :	15.00	15.00	0.00
	CUM GPA : 0.00	CUM TOTALS :	340.00	340.00	0.00

2006 Winter Quarter

Program : Environmental Toxicology Grad
Plan : Environmental Toxicology PhD Graduate Course of Study

ETOX	281F	Topics Aquatic Tox	5.00	5.00	A
ETOX	292	Intro Grad Seminar		0.00	S
ETOX	299B	Thesis Research	10.00	10.00	A
	TERM GPA : 0.00	TERM TOTALS :	15.00	15.00	0.00
	CUM GPA : 0.00	CUM TOTALS :	355.00	355.00	0.00

2006 Spring Quarter

Program : Environmental Toxicology Grad

Plan : Environmental Toxicology PhD Graduate Course of Study

ETOX	299C	Thesis Research	15.00	15.00	A	
	TERM GPA :	0.00	TERM TOTALS :	15.00	15.00	0.00
	CUM GPA :	0.00	CUM TOTALS :	370.00	370.00	0.00

Graduate Career Totals

CUM GPA :	0.00	CUM TOTALS :	370.00	370.00	0.00

- - - - - Non-Course Milestones - - - - -

Graduate Candidacy - Advanced to Candidacy

2004 Spring Quarter

- Completed

Graduate Qualifying Exam - Graduate Qualifying Examination Passed

- Completed

Graduate Language Exam - None Required

- Completed

Return to